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U.S. DEPARTMENT OF COMMERCE
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Notice

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Development of Cost Effective Techniques for Alleviating Water Supply Deficiencies in a Residential Sprinkler System

by

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Abstract

Simple cost effective techniques for alleviating water supply deficiencies in a residential sprinkler system installed in a one- or two-family dwelling have been examined. The equipment associated with compensating for an inadequate municipal water supply using water storage tanks, booster pumps, and large diameter pipe have been investigated for efficiency and cost effectiveness.

Hydraulically-designed, NFPA 13D, residential sprinkler systems in seven residences were used to carry out this research. The seven selected floor plans of one- and two-family dwellings included in this project were representative of a wide range of designs currently being utilized in actual residential subdivisions under construction at the time of the project in the Baltimore-Washington area.

The simple technique for determining the installation cost of a sprinkler system was formulated following an analysis of the sprinkler system versus the key design features of the dwelling. Emphasis was placed on developing a technique which ws accurate and easy to apply with minimal time and effort.

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1. INTRODUCTION

Automatic sprinkler systems installed in residential occupancies have been postulated to significantly reduce the life loss due to fire (1-4). Except for a collection of case studies from a limited number of actual fire incidents involving the operation of a residential sprinkler system, the data base is insufficient to permit an empirical analysis of performance (2). Analyses by Budnick (3) and Gomberg (4) have been conducted projecting the potential impact of a residential sprinkler system. Budnick (3) postulated the capability of a residential sprinkler system to protect building occupants as a function of selected fire scenarios and occupant characteristics. Gomberg (4) used a decision model to estimate the impact of a residential sprinkler system.

Typically the presence of sprinkler systems in commercial occupancies is mandated by building codes or recommended by the insurance underwriters. The installation of a sprinkler system involves an additional construction cost to a building. However, in commercial occupancies numerous design options are available to offset the additional cost of the sprinkler system. Unlike commercial construction, there are no widely recognized trade-offs in residential construction which can be taken advantage of in one- and two-family residential dwellings.

Thus, in the absence of code mandates, design options, or incentives from insurance, it is doubtful residential sprinkler systems can gain widespread acceptance by the public without being inexpensive (5). In 1980, Shaw identified the need to

assess the cost effectiveness of residential sprinkler systems as part of an effort to increase the acceptance of these systems by the general public (5). Since that time, numerous projects have been conducted to assess the cost effectiveness of individual system components such as a backflow prevention device (6). Economic analysis of residential sprinkler systems have been conducted to estimate installation costs and fees and incentives such as tax or insurance premium reductions (3-5, 7-9).

The installation cost of a residential sprinkler system is dependent on the design parameters of the system. The influential system design parameters include, length, diameter and type of pipe, number of sprinkler heads, fittings, valves and miscellaneous other components, as well as labor costs for installation, design costs and local fees (5). The water supply often entails a major cost associated with commercial sprinkler systems. For residential sprinkler systems, the water supply cost may be substantial if it is necessary to supplement an inadequate municipal water supply or provide a water supply source where none exists.

Supplementing an inadequate water supply system can be accomplished by several means, including water storage tanks (pressurized or unpressurized), booster pumps, large diameter pipe and variations in piping configuration. A cost and level of effectiveness can be associated with each supplementary means of correcting the water supply inadequacy.

2. WATER SUPPLY REQUIREMENTS

Minimum water flow requirements for residential sprinkler systems are stipulated in NFPA 13D, "Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes" (10). Considering these stipulations, a hydraulic analysis can be performed to determine the water flow and pressure required to adequately supply the sprinkler system.

2.1 NFPA 13D Requirements

NFPA 13D includes requirements for the minimum water demand rate from one and two sprinklers flowing and the minimum flow duration to be considered if water is placed in storage for sprinkler protection. The design criteria for the water demand rate is as follows:

1. 18 gallons per minute (gpm) (68 liters per minute) from one operating sprinkler head.
2. 13 gpm (49 liters per minute) from each of two operating sprinkler heads.

If water is placed in storage for sprinkler protection, a sufficient quantity must be stored to provide at least the water demand rate (26 gpm) for a minimum of ten minutes, i.e. 260 gallons.

2.2 Hydraulic Analysis of Water Demand Requirements

A hydraulic analysis can be performed to determine the domestic water pressure and flow characteristics necessary to adequately supply the residential sprinkler system and comply with NFPA 13D criteria. The results of a hydraulic analysis will

be dependent on the sprinkler head, pipe diameter, length and configuration, elevation changes, and diameter of meter, valves and fittings. In order to conduct this portion of the study, residential sprinkler systems were designed by Clark and Coutts (11) for seven different residences. The floor plans for the seven residences were obtained from construction sites in the Baltimore, Maryland - Washington, D.C. area.

The seven floor plans were selected based on a desire to develop designs for a diverse group of residences, while limiting the number of plans included in the study to a reasonable level. The dwellings ranged in floor area from 1,482 to 3,480 square feet.

The design of the sprinkler systems for the seven residences was based on the requirements of NFPA 13D (10). Sprinkler protection was provided in sleeping, living and working areas. since NFPA 13D does not require protection in certain areas, no sprinkler protection was provided in small bathrooms; attached porches and garages; and attics and crawl spaces not used or intended for living purposes or storage. Schematic designs of the sprinkler systems for the seven residences are included in Appendix A.

A comprehensive discussion of the sprinkler system design details and hydraulic analysis are included in a report by Clark and Coutts (11).

2.2.1 Sprinkler Head Locations

The total room areas were used to calculate the minimum number of sprinkler heads required for each room. The maximum

coverage area criterion of 144 square feet per head from NFPA 13D was utilized (10). Sprinkler heads were located within the rooms as symmetrically as possible. The separation distance between sprinklers was 8 to 12 feet. The maximum distance between a sprinkler and a wall was limited to 6 feet. Sidewall sprinklers were located primarily in corridors.

2.2.2 Sprinkler System Pipe Layout

The sprinkler system was connected to the domestic water supply, ahead of the water meter. Riser locations were intended to be representative of typical domestic water supply locations. Pipe configurations were selected to minimize the distance to the riser and the total length of pipe. To simplify installation, all pipe was chosen to be the same diameter.

The domestic supply was assumed to be a 1 inch copper pipe. The distance to the city main from the domestic riser was arbitrarily selected as 25.0 feet for all residences. The city main was assumed to be unlined 8 inch cast iron pipe buried 3.0 feet below ground level, as is typical in the Baltimore, Maryland-Washington, D.C. area. Other details of the residential sprinkler system designs may be obtained from Appendix A.

2.2.3 Sprinkler Head Performance Criteria

NFPA 13D requires a sprinkler discharge of 18 gpm for a single operating sprinkler, and 13 gpm each for two sprinklers operating in the same room. The minimum pressure required at the

head for the two flow requirements can be derived from the relationship:

$$Q = k\sqrt{p}$$

Where Q = flow from sprinkler head, (gpm)

k = constant, from manufacturer's literature

p = water pressure required (psi)

Using a k value of 3.85, representative of a typical residential sprinkler head, the minimum pressures at the sprinkler heads were determined as follows:

One operating sprinkler (18 gpm): 21.9 psi

Two operating sprinklers (13 gpm): 11.4 psi

2.2.4 Water Demand Requirement

Sprinkler head requirements were entered into Hypercalc version 4.0 (12) along with other system parameters including pipe distances and diameters, fitting details, etc. The analysis was conducted for sprinkler systems with 3/4 inch and 1 inch CPVC plastic pipe. All risers were assumed to be 1 inch, schedule 10 steel. In addition, only schedule 10 steel pipe was used in the basement because of the likelihood of the pipe being exposed.

The water demand requirement was calculated at a reference point on the municipal water supply system, labeled hydrant C, such that the pressure requirements were met at the remote sprinkler head(s). The distance to hydrant C on the municipal system was maintained constant for all residences at an arbitrarily selected value of 250 feet. Obviously, this distance could change with different house locations in actual situations. However the affect of this distance variation is considered

insignificant due to the negligible friction losses associated with the low flow rate encountered in an 8 inch pipe. The water demand requirements at the point of cross-connection of the residential sprinkler system with the domestic water system (point AA on the schematics in Appendix A) for the seven residences and two diameters of CPVC pipe are included in Table 1. The water demand requirement at hydrant C for the seven residences using 3/4 inch and 1 inch CPVC pipe are presented in Table 2.

The water demand requirements were determined assuming metering of the sprinkler system was not required. This practice is common in commercial occupancies and has been permitted in residential occupancies in some instances. However, based on a telephone survey of water company authorities in the Baltimore, Maryland - Washington, D.C. metropolitan area, all authorities reported that single-family residential fire sprinkler systems must be metered.

Metering of the sprinkler system affects the water demand requirements in two ways. First, flow through the meter is accompanied by friction loss. The magnitude of the friction loss depends on the water flow rate and meter size. The friction losses associated with water meters noted in Table 4-4.3 (d) of NFPA 13D is included in Appendix B. The friction losses indicated in the table are conservative, considering the variety of water meters available.

The water demand requirements noted in Tables 1 and 2 can be adjusted to account for the friction loss of the meters. The

adjusted water demand requirements are noted in Tables 3-6 for 5/8 inch and 3/4 inch meters, using the friction loss data cited in NFPA 13D.

The second possible effect of metering the sprinkler system entails a pressure reducing valve (PRV). PRV's are required in many jurisdictions by plumbing code officials for new construction. A PRV limits the maximum water pressure in the domestic water system to a preset value, typically between 60 and 80 psi. Friction loss also results from water flow through the PRV. The friction loss for typical PRV's installed in single family residences ranges from 10 to 15 psi for 18 gpm and 15-20 psi for 26 gpm. The actual friction loss will depend on the PRV model, water supply pressure to the valve and valve setting.

NFPA 13D suggests that the point of cross-connection of the residential sprinkler system with a domestic water supply be before the PRV (10). This is to avoid the substantial friction associated with the valve. However in some instances, this may not be readily accomplished because of space limitations or other factors. The options of connecting before or after the PRV will be elaborated on in more detail in a subsequent section of this report.

Bar graphs are provided in Figures 1-7 depicting the variations in the water demand requirements at the cross-connection point for each of the seven residences, considering different pipe diameters (3/4 and 1 inch CPVC) and water meter sizes (5/8 and 3/4 inch).

2.3 Available Water Supply

The previous section described the water demand requirements of residential sprinkler system designs in seven dwellings. The domestic water system must be able to meet the demand requirements in order to be considered as an adequate supply source.

Data on the available water supply provided by the Washington Suburban Sanitary Commission (WSSC) is presented in Table 7 (11). This data was acquired from water flow tests in the Maryland suburbs of Washington, D.C. This data is considered to be typical of that available in the Washington, D.C. area.

According to the water authorities surveyed in the Washington, D.C. area, design guidelines for water distribution systems in new residential subdivisions specify that the static pressure should be pressure between 30 and 80 psi. A water flow rate of at least 1,000 gpm at 20 psi is dictated to meet the fire flow requirement.

An attempt was made to supplement the data from WSSC by conducting water flow tests at numerous residences in the Baltimore, Maryland - Washington, D.C. area. The tests were conducted by flowing water from the garden hose outlet located on the exterior of the residence. The static pressure, residual pressure and water flow rate were recorded. However, the data obtained from these tests could not be accurately interpretted. Difficulties in interpretation were experienced since the water supply characteristics obtained by the test needed to be related to that available at the meter by a hydraulic analysis. Because

the flow characteristics of the hose outlet valve were not known and the effect of the PRV (if present) could not be reliably quantified, a hydraulic analysis was not conducted.

The lack of information inhibiting the analysis of the flow data is a noteworthy gap in the assessment of the adequacy of domestic water supply systems. Research is needed to properly characterize residential plumbing flow devices in residences so that homeowners can make an assessment of the adequacy of the domestic water supply system by performing an elementary test. This recommended research effort should also consider if an inexpensive apparatus need to be developed to facilitate homeowner testing of the water supply within the residence.

2.4 Adequacy of Available Water Supply

The adequacy of the domestic water supply can be evaluated by comparing the characteristics of the available water supply with the water demand requirements. The comparison can be performed based on demand and available water supply data at the point of cross-connection and at hydrant C, respectively. The validity of this comparison is based on the assumption that the characteristics of the available water supply do not vary appreciable from the hydrant to the point of cross-connection.

The water supply data in Table 7 from the WSSC tests can be compared with the water demand requirements depicted in Table 2. In this case, assessing the adequacy of the water supply can be conducted either by considering or neglecting the effects of a water meter. The results of this means of comparison is included in Figure 8.

2.5 Methods to Supplement Inadequate Water Supplies

If only the pressure is judged to be inadequate, a pump may be used to supplement the water supply. If both the pressure and flow is deficient, then a pump and tank is required to adequately supplement the water supply.

For the case of NFPA 13D residential sprinkler systems with the comparitively low flow requirements, no pumps or tanks are listed solely for fire protection use. Thus, any cold-water booster pump with the appropriate pressure-flow relationship may be acceptable. In this context, an "appropriate" pressure-flow relationship is one that satisfies the water demand requirements of the system. The capacity of the water tank must be at least 260 gallons. A composite pump and tank assembly, including all necessary valves for a residential sprinkler system, is also available (13).

Clark and Coutts used the characteristics of the pump in the composite pump and tank assembly to address the capability of the pump to adequately supplement a pressure-deficient water supply (11). The pump characteristics are noted below:

no flow: 50 psi

18 gpm: 43 psi

26 gpm: 41 psi

Considering the pump characteristics and the water flow data obtained from WSSC, the pump was found to be capable of adequately supplementing pressure deficient water supplies. This assessment was performed by summing the pressure supplied by the pump and that provided by the available water supply system for a

particular flow rate. For example, at 26 gpm, the supplemented water supply would provide 41 psi in excess of that determined from the WSSC data.

The addition of a tank provides the capability of either supplementing a pressure and flow deficient water supply or independently supplying the sprinkler system. An advantage of using the tank to be the sole supply for the sprinkler system is the elimination of the need to cross-connect the domestic water and sprinkler systems.

The adequacy of the pump-tank combination unit can be assessed by examining the water demand requirements listed in Table 1. The combination unit can adequately supply the residential sprinkler systems which include all 1 inch pipe. The residences with sprinkler systems using 3/4 inch pipe not adequately supplied by the pump-tank combination are listed in Table 8. All of the residences listed in Table 8 are two story models having the greatest elevation change from the point of cross-connection to the uppermost sprinkler head of any included in this study. The inadequacy could be greatly alleviated if the pump-tank combination unit was installed in the attic or on the second story of the residence to eliminate the elevation head loss. However, placement of the water tank in the attic or second story could necessitate a modification in the design of the structure to accomodate the additional load imposed by the filled water tank.

3. RESIDENTIAL SPRINKLER SYSTEM INSTALLATION COST

3.1 Cost Estimation Methods

A principal portion of a study of cost-effectiveness involves determining the cost of a system. Previously presented estimates of the cost of a sprinkler system installed in a residence have been based on one of three approaches (7):

a) construction cost estimating technique, considering each component.

b) engineering judgement.

c) rule-of-thumb guidelines.

A component construction cost estimating technique considers the sum of the material and labor costs associated with each system component. The cost resulting from this technique is expressed in terms of a total system cost, which may be normalized with respect to the overall construction cost or living space area of the dwelling. Such a method for developing cost estimates for a residential sprinkler system was used by Rolf Jensen and Associates (RJA) (14). Components considered in the analysis included typical sprinkler system components such as piping, sprinkler heads, and a control valve in addition to special components such as a larger water service meter and booster pump to supplement a marginal municipal water supply. These costs can be modified to account for design and permit fees, local economic conditions, etc.

Estimates based on engineering judgement have been presented in numerous publications (7). As with the component cost estimating technique, costs may be presented in terms of a total system cost or cost per square foot (15,16). With this

estimating technique, typically the projected cost is insensitive to housing design, design parameters of the sprinkler system and water supply characteristics.

Finally, the rule-of-thumb approach expresses the cost of a residential sprinkler system as a percentage of the total construction cost. Previously suggested rule-of-thumb estimates project the sprinkler system cost to range from one to two percent of the overall construction cost. As with the engineering judgement based estimates, the rule-of-thumb estimates are insensitive to housing design, design parameters of the sprinkler system and water supply characteristics.

Based on the discussion in section 2 of this report, the cost of a residential sprinkler system would appear to be strongly dependent on the available water supply. In situations where the municipal supply is marginal or nonexistant, the design must account for the supplemental means needed to offset the water supply deficiencies (7,14). As a result, it would appear that the rule-of-thumb guidelines previously presented for estimating the cost of a residential sprinkler system may be inappropriate where the water supply is deemed inadequate.

3.2 Application of Component Cost Method

Adams and Born (17) used the component cost method to estimate the installation cost of the sprinkler systems for the seven residences designed by Clark and Coutts (11). The estimates were based on the installation costs for a new residence. Adams and Born expanded the analysis beyond that considered by Clark and Coutts by including five different pipe

types: 3/4 and 1 inch CPVC, 3/4 and 1 inch polybutylene and 1 inch schedule 10 steel for levels other than the basement (17) (1 inch scheduled 10 steel was used in the basement).

Components lists were compiled for each residence and pipe type, e.g. one component list was formulated for the three bedroom ranch house with 3/4 inch CPVC pipe. Material costs for each component were obtained from price lists supplied by local distributors to residential sprinkler system contractors. The Means Mechanical Costs Data was used to obtain price information on components if such information was not otherwise available (18). This reference was also used to estimate all labor expenses, rather than use rule-of-thumb estimates that may be used by contractors. A 35 percent surcharge was added as the typical mark-up for profit by the contractor as recommended by the Means reference (18).

Material, labor and profit costs from the Adams and Born analysis for the seven residences are included in Figures 9-15. Material, labor and profit costs are summed to determine the sprinkler system cost if installed by a contractor. If installed by the homeowner, only the material costs are included to estimate the cost of the sprinkler system.

As indicated in Figures 9-15, the material costs are not affected by who the installer is, i.e. contractor or homeowner. In reality, contractors typically purchase materials from distributors at appreciable discounts. In addition, a homeowner may not be able to readily acquire threaded steel pipe, at specified lengths without paying a surcharge. Further, cutting

and threading schedule 10 steel pipe may be beyond the capability of many homeowners, even if the appropriate tools are acquired.

The installation costs of a pump and tank to supplement the water supply were also examined by Adams and Born. These are noted in Figures 9-15 as being a fixed cost, i.e. independent of the residence, pipe diameter type, or installer. The cost of the pump was estimated as $551, based on the Means book (18). The cost of the tank was selected as $210, also based on the Means book (18).

Cost items other than those previously noted also may be a part of the actual total installation cost. Additional costs will be incurred if a double check valve or backflow preventer is required by the local water authority or plumbing code official. A water meter with an increased diameter may be necessitated due to hydraulic considerations. Cost estimates of water meters, double check valves and backflow preventers are included in section 4 of this report. Miscellaneous additional costs which may be applicable include tie in fees assessed for the interconnection to the municipal water supply, permit fees, design fees and inspection fees.

3.3 Cost Estimation Guidelines

Cost estimation guidelines were developed by Adams and Born. Graphs are presented in Figures 16-20 depicting the total installation cost versus the total floor area for each of the five pipe types. The installation cost includes the material, labor and profit costs as estimated by the component cost method. Special fees and the cost of the tank and pump are not included.

A linear regression analysis was conducted on the data presented in Figures 16-20. Correlations resulting from the analysis are presented in Table 9. A procedure for estimating the installation cost of residential sprinkler systems using the correlations, including the cost of a pump and tank if necessary, is presented in Table 10.

4. COST EFFECTIVENESS OF DESIGN OPTIONS

The two design options addressed in this report are large diameter pipe and self-contained systems. Numerous other options could be considered, such as pipe configuration, more extensive use of sidewall heads, etc. These other design options are not addressed in this report as they were considered to have less impact on the overall system cost-effectiveness than the two selected options.

4.1 Cost Effectiveness of Large Diameter Pipe

The hydraulic analysis and cost estimates have been presented for residential sprinkler systems with 3/4 and 1 inch CPVC pipe. The demand pressures noted in Table 1 can be compared for systems with 3/4 and 1 inch CPVC pipe in the seven residences. The difference in the demand pressure ranges from 5 to 10 psi for one operating sprinkler and 9-18 psi for two operating sprinklers.

The installation cost for the 3/4 inch CPVC pipe is less than that for the 1 inch CPVC pipe in each of the seven residences. According to the correlations presented in Table 9, the installation cost of a residential sprinkler system with 3/4 inch CPVC pipe is less than that associated with the 1 inch CPVC pipe

for any dwelling (as long as the total floor area is in excess of 92 sq. ft.).

The additional cost associated with the use of 1 inch CPVC pipe can be justified if a reduction in the water demand pressure at 18 or 26 gpm is needed. A reduction in the water demand pressure may be necessitated if the available water supply system is inadequate.

As an alternative to the 1 inch CPVC pipe, 3/4 inch CPVC pipe may be used with a pump. In this case, the supplemented water supply should most likely be capable of delivering 18 gpm and 26 gpm at the respective demand pressures. However, the additional cost of the pump results in the system with 3/4 inch CPVC pipe being more costly for any residence with a floor area of less than 3,320 sq. ft., according to the correlations presented in Table 10.

Residential sprinkler systems with 1 inch polybutylene (PB) pipe are less expensive than systems with 3/4 inch PB pipe for any residence with a floor area of less than 3,980 sq. ft. This observation is counter-intuitive and is attributable to the additional cost of fittings for the 3/4 inch PB system based on the information available (17). Thus, since the 1 inch PB pipe performs better hydraulically and is less expensive for most residences, the 1 inch PB pipe appears to be the more cost-effective of the two sizes of PB pipe.

A hydraulic analysis was not performed for designs with PB pipe or steel pipe. These additional hydraulic analyses were not conducted since the friction loss through the pipe sections for

CPVC was not observed to be substantial. Thus, changes in pipe composition would appear to have little impact on the overall friction loss, thereby having a second-order effect on the water demand requirement.

4.2 Cost Effectiveness of Self-Contained Systems

Self-contained residential sprinkler systems are not connected to the domestic water supply system. A pump and tank are needed in a self-contained system to provide the water flow rate, pressure and duration required by NFPA 13D (10). A list of residences not adequately supplied by 3/4 inch CPVC, pump and tank is included in Table 8. As previously noted, the deficiencies could be appreciably reduced if the tank and pump is located in the attic or on the second floor.

The cost of the pump and tank is $761. Correlations to estimate the cost of a self-contained system can be developed by adding $761 to those listed in Table 9. One advantage of a self-contained system is the elimination of the need for a larger meter (to reduce friction loss) and a backflow prevention device. Cost estimates for 3/4 and 1 inch meters and backflow prevention devices are listed in Appendix C based on information provided by local distributors and the Means book (18).

A self-contained system with 3/4 inch CPVC pipe is less expensive than a residential sprinkler system cross-connected to the domestic water supply with a 3/4 inch meter, 3/4 inch double check valve and 1 inch CPVC pipe for any residence greater than 2900 sq. ft. in floor area. The floor areas at which the 3/4 inch CPVC pipe, self-contained system becomes less costly than a

cross-connected system with 1 inch CPVC pipe and different meter sizes and backflow prevention devices and sizes are noted in Table 11.

Some fees may be included for sprinkler systems cross-connected to domestic water systems. If additional fees apply, the floor area will decrease from that noted above at which point self-contained sprinkler systems become less costly.

The cost of self-contained sprinkler systems can also be compared to that for a cross-connected sprinkler system with a pump, increased meter size and a backflow prevention device. The self-contained system with 3/4 inch CPVC pipe is approximately $70 less costly than a cross-connected sprinkler system with 3/4 CPVC pipe, a 3/4 inch meter and 3/4 inch double check valve. The difference increases to $130 if a backflow preventor is used instead of a double check valve on the cross-connected system. In this case, to compare the cost effectiveness of the self-contained sprinkler system with the cross-connected sprinkler system with a pump, the importance of the limited water flow duration (10 minutes) of the self-contained system must be assessed. This assessment will need to consider the objectives of the residential sprinkler system. If the sole objective is life safety of the occupants, then a 10 minute flow duration likely would be sufficient and the self-contained system would be more cost effective. However, if property protection is an objective, then a water flow duration in excess of 10 minutes may be desirable.

5. SUMMARY

An investigation of the cost effectiveness of residential sprinkler systems has been conducted in two phases. First, water demand requirements for residential sprinkler systems in seven residences were determined and compared with data describing the available water supply in the Baltimore, Maryland - Washington, D.C. area. Second, the installation cost of the residential sprinkler systems was estimated for homeowner or contractor installed systems.

The following conclusions resulted from this investigation:

1. A technique was developed to determine the cost effectiveness of methods to alleviate water supply deficiencies for residential sprinkler systems.

2. A pump can adequately supplement a pressure-deficient domestic water supply to serve a residential sprinkler system.

3. A pump-tank combination unit can adequately supply a self-contained residential sprinkler system.

4. Using 1 inch CPVC pipe is more cost-effective that 3/4 inch CPVC pipe with a pump for residences less than 3,320 sq. ft. in floor area.

5. Self-contained residential sprinkler systems are as cost-effective as residential sprinkler systems cross-connected to a domestic water suply for providing life safety to the occupants.

6. Additional research is needed to develop a means of assessing the characteristics of an existing municipal water supply to determine if such supply is adequate for a residential sprinkler system.

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16. Jensen, R., "Development of the NFPA 13D Residential Sprinkler Standard", Proceedings of the 4th Conference on Low-Cost Residential Sprinkler Systems, Washington, D.C., September 26, 27, 1979.

17. Adams, Scott W. and Christopher H. Born, "Cost Estimations of Residential Sprinkler Systems, Including Cases where Municipal Water Supply is Inadequate or Non-Existant", Department of Fire Protection Engineering, University of Maryland, May, 1987, unpublished.

18. <u>Means Mechanical Costs Data 1986</u>, R.S. Means Company, Inc., 1985.

Table 1 Water Demand Requirements (PSI) at Cross-Connection Point

	3/4 inch CPVC Pipe		1 inch CPVC Pipe	
Residence	One Operating Sprinkler	Two Operating Sprinklers	One Operating Sprinkler	Two Operating Sprinklers
Ranch-3 Bedroom (Style 1)	32.1	28.7	27.3	19.2
Ranch-3 Bedroom (Style 2)	40.8	38.9	30.7	23.1
Colonial-3 Bedroom	44.2	47.8	36.6	32.5
Colonial-5 Bedroom	45.4	44.4	34.7	27.7
Townhouse-2 Bedroom	38.2	43.0	31.7	27.2
Townhouse-3 Bedroom	43.4	49.4	35.8	31.6
Split Level-3 Bedroom	38.1	34.0	31.5	23.5

Table 2 Water Demand Requirements (PSI) at Hydrant*

	3/4 inch CPVC Pipe		1 inch CPVC Pipe	
Residence	One Operating Sprinkler	Two Operating Sprinklers	One Operating Sprinkler	Two Operating Sprinklers
Ranch-3 Bedroom (Style 1)	38.4	39.4	33.6	29.9
Ranch-3 Bedroom (Style 2)	47.1	49.6	36.1	33.9
Colonial-3 Bedroom	50.8	56.8	42.9	41.4
Colonial-5 Bedroom	51.7	55.2	41.0	38.5
Townhouse-2 Bedroom	44.5	53.8	38.0	37.9
Townhouse-3 Bedroom	49.7	60.1	42.1	42.3
Split Level-3 Bedroom	44.4	44.7	37.8	34.2

*Friction Loss Through Meter Neglected.

Table 3 Water Demand Requirements (PSI) at Cross-Connection Point with 5/8 inch meter.

	3/4 inch CPVC Pipe		1 inch CPVC Pipe	
Residence	One Operating Sprinkler	Two Operating Sprinklers	One Operating Sprinkler	Two Operating Sprinklers
Ranch-3 Bedroom (Style 1)	41,1	46.7	36.3	37.2
Ranch-3 Bedroom (Style 2)	49.8	56.9	39.7	41.1
Colonial-3 Bedroom	53.2	65.8	45.6	50.5
Colonial-5 Bedroom	54.5	62.4	43.7	45.7
Townhouse-2 Bedroom	47.2	61.0	40.7	45.2
Townhouse-3 Bedroom	52.4	67.4	44.8	49.6
Split Level-3 Bedroom	47.1	52.0	40.5	41.5

Table 4 Water Demand Requirements (PSI) at Cross-Connection Point with 5/8 inch meter.

Residence	3/4 inch CPVC Pipe One Operating Sprinkler	 Two Operating Sprinklers	1 inch CPVC Pipe One Operating Sprinkler	 Two Operating Sprinklers
Ranch-3 bedroom (Style 1)	36.1	37.7	31.3	28.2
Ranch-3 Bedroom (Style 2)	44.8	56.8	40.6	41.5
Colonial-3 Bedroom	48.2	56.8	40.6	41.5
Colonial-5 Bedroom	49.4	53.4	38.7	36.7
Townhouse-2 Bedroom	42.2	52.0	35.7	36.2
Townhouse-3 Bedroom	47.4	58.4	39.8	40.6
Split Level-3 Bedroom	42.1	43.0	35.5	32.5

Table 5 Water Demand Requirements (PSI) at Hydrant*

Residence	3/4 inch CPVC Pipe: One Operating Sprinkler	3/4 inch CPVC Pipe: Two Operating Sprinklers	1 inch CPVC Pipe: One Operating Sprinkler	1 inch CPVC Pipe: Two Operating Sprinklers
Ranch-3 Bedroom (Style 1)	47.4	57.4	42.6	47.9
Ranch-3 Bedroom (Style 2)	56.1	67.6	45.1	51.9
Colonial-3 Bedroom	59.8	74.8	51.9	59.4
Colonial-5 Bedroom	60.7	73.2	50.0	56.5
Townhouse-2 Bedroom	53.5	71.8	47.0	55.9
Townhouse-3 Bedroom	58.7	78.1	51.1	60.3
Split Level-3 Bedroom	53.4	62.7	46.8	52.2

* Friction loss through 5/8 inch meter included

Table 6 Water Demand Requirements (PSI) at Hydrant*

Residence	3/4 inch CPVC Pipe One Operating Sprinkler	3/4 inch CPVC Pipe Two Operating Sprinklers	1 inch CPVC Pipe One Operating Sprinkler	1 inch CPVC Pipe Two Operating Sprinklers
Ranch-3 Bedroom (Style 1)	42.4	48.4	37.6	38.9
Ranch-3 Bedroom (Style 2)	51.1	58.6	40.1	42.9
Colonial-3 Bedroom	54.8	65.8	46.9	50.4
Colonial-5 Bedroom	55.7	64.2	45.0	47.5
Townhouse-2 Bedroom	48.5	62.8	42.0	46.9
Townhouse-3 Bedroom	53.7	69.1	46.1	51.3
Split Level-3 Bedroom	48.4	53.7	41.8	43.2

* Friction loss through 3/4 inch meter included

Table 7 Municipal Water Supply Data

1. SUB-DIVISION: Gaithersburg

   STATIC: 87 psi
   RESIDUAL: 79 psi
   PITOT: 78 psi @ 1480 gpm

   GPM @ 20 PSI: 4600 gpm

2. SUB-DIVISION: Hillmeade Manor

   STATIC: 55 psi
   RESIDUAL: 22 psi
   PITOT: < 2 psi @ 240 gpm

   GPM @ 20 PSI: 248 gpm

3. SUB-DIVISION: Landover

   STATIC: 48 psi
   RESIDUAL: 42 psi
   PITOT: 42 psi @ 1090 gpm

   GPM @ 20 PSI: 2504 gpm

4. SUB-DIVISION: High Bridge Estates

   STATIC: 47 psi
   RESIDUAL: 38 psi
   PITOT: 18 psi @ 710 gpm

   GPM @ 20 PSI: 1285 gpm

5. SUB-DIVISION: Bowie

   STATIC: 52 psi
   RESIDUAL: 29 psi
   PITOT: 25 psi @ 840 gpm

   GPM @ 20 PSI: 1004 gpm

6. SUB-DIVISION: Camelot

   STATIC: 25 psi
   RESIDUAL: 16 psi
   PITOT: 6 psi @ 410 gpm

   GPM @ 20 PSI: 298 gpm

7. SUB-DIVISION: College Park

STATIC: 112 psi
RESIDUAL: 64 psi
PITOT: 34 psi @ 995 gpm

GPM @ 20 PSI: 1415 gpm

Table 8. Residential Sprinkler Systems with Water Demand Requirements Exceeding Pump Capabilities*

<u>One Operating Sprinkler Head</u>

Colonial - 3 bedroom
Colonial - 5 bedroom
Townhouse - 3 bedroom

<u>Two Operating Sprinkler Systems</u>

Colonial - 3 bedroom
Colonial - 5 bedroom
Townhouse - 2 bedroom
Townhouse - 3 bedroom

*All sprinkler systems have 3/4 inch CPVC pipe.

Table 9 Cost Estimation Correlations

Contractor - Installed

Pipe Type	Correlation	Correlation Coefficient
3/4 inch CPVC	$C = 1.06A + 279$	0.96
1 inch CPVC	$C = 1.23A + 263$	0.98
3/4 inch PB	$C = 1.07A + 353$	0.95
1 inch PB	$C = 1.10A + 234$	0.96
1 inch Steel	$C = 1.37A + 381$	0.99

Homeowner Installed

Pipe Type	Correlation	Correlation Coefficient
3/4 inch CPVC	$C = 0.18A + 213$	0.95
1 inch CPVC	$C = 0.26A + 230$	0.93
3/4 inch PB	$C = 0.16A + 266$	0.91
1 inch PB	$C = 0.20A + 190$	0.97
1 inch Steel	$C = 0.10A + 179$	0.99

Where:

A = total floor area of residence (sq. ft)

C = installation cost ($)

Table 10. Procedure for Estimating Residential Sprinkler System Installation Cost*

1. Enter total floor area of residence ________

2. Enter factor X (see Table 10.1) ________

3. Multiply line 1 by line 2 ________

4. Enter factor Y (see Table 10.1) ________

5. Subtotal. Add line 3 and line 4 ________

6. Is a pump necessary?
   If yes, enter $551. Otherwise
   enter 0 and continue to one 7. ________

7. Is a tank necessary?
   If yes, enter $210. Otherwise
   enter 0 and continue to line 8. ________

8. Total Cost. Add lines 5, 6 and 7 ________

Table 10.1. Estimation Factors

Pipe Description	Factor X	Factor Y
3/4 inch CPVC	1.06	279
1 inch CPVC	1.23	263
3/4 inch PB	1.07	353
1 inch PB	1.10	234
1 inch Steel	1.37	381

*Estimated cost is for a contractor-installed system using one of the 5 pipe types listed in Table 10.1

Table 11 Marginal Floor Area for Self-Contained Residential Sprinkler System

Backflow Prevention Device and Meter	Floor Area (sq. ft.)*
3/4 inch double check valve and meter	2,900
3/4 inch backflow preventer and meter	2,420
1 inch double check valve and meter	2,540
1 inch backflow preventer and meter	1,930

* Floor area noted is the minimum area for self-contained residential sprinkler system to be less expensive that residential sprinkler system connected to domestic water supply with noted backflow prevention device and meter

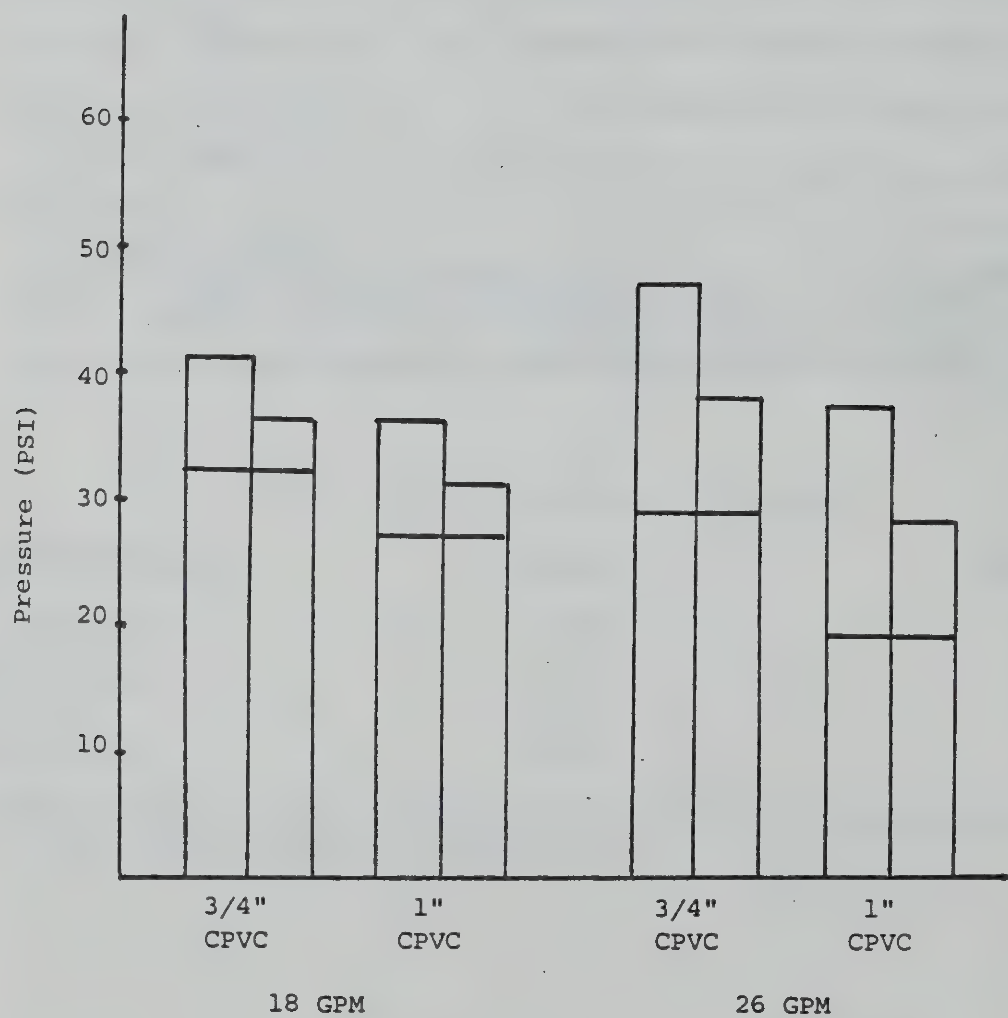


Figure 1. Water Pressure Demand Requirements for Ranch House, Style 1, 3 Bedrooms (1,482 sq. ft.)

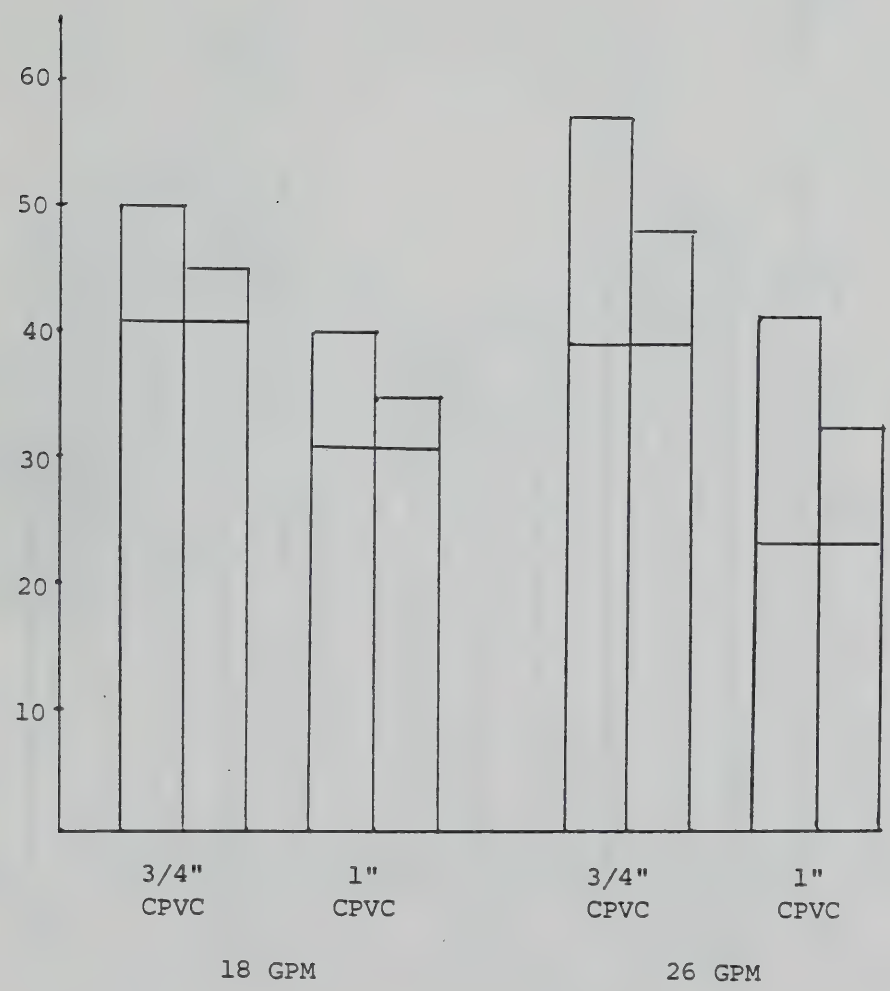


Figure 2. Water Pressure Demand Requirements for Ranch House, Style 2, 3 Bedrooms (2,140 sq. ft.)

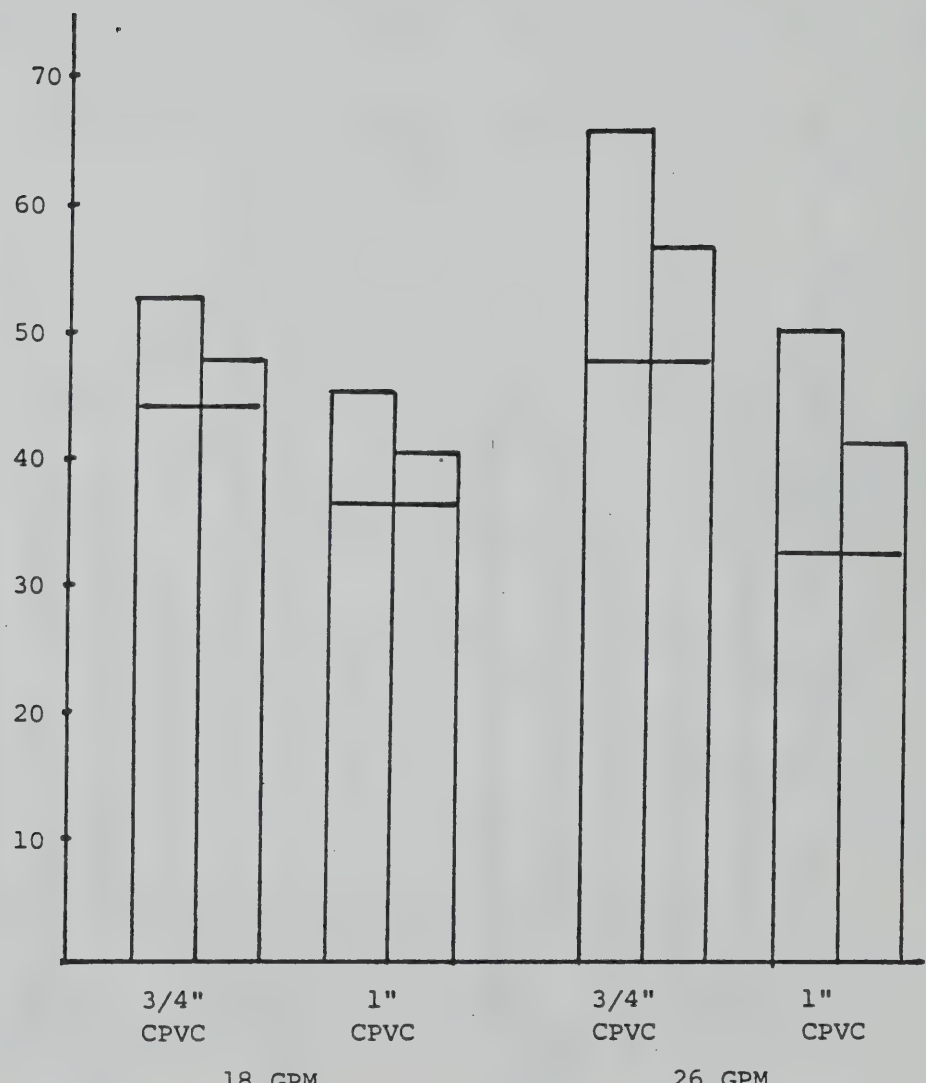


Figure 3. Water Pressure Demand Requirements for Colonial House, 3 Bedrooms (2,168 sq. ft.)

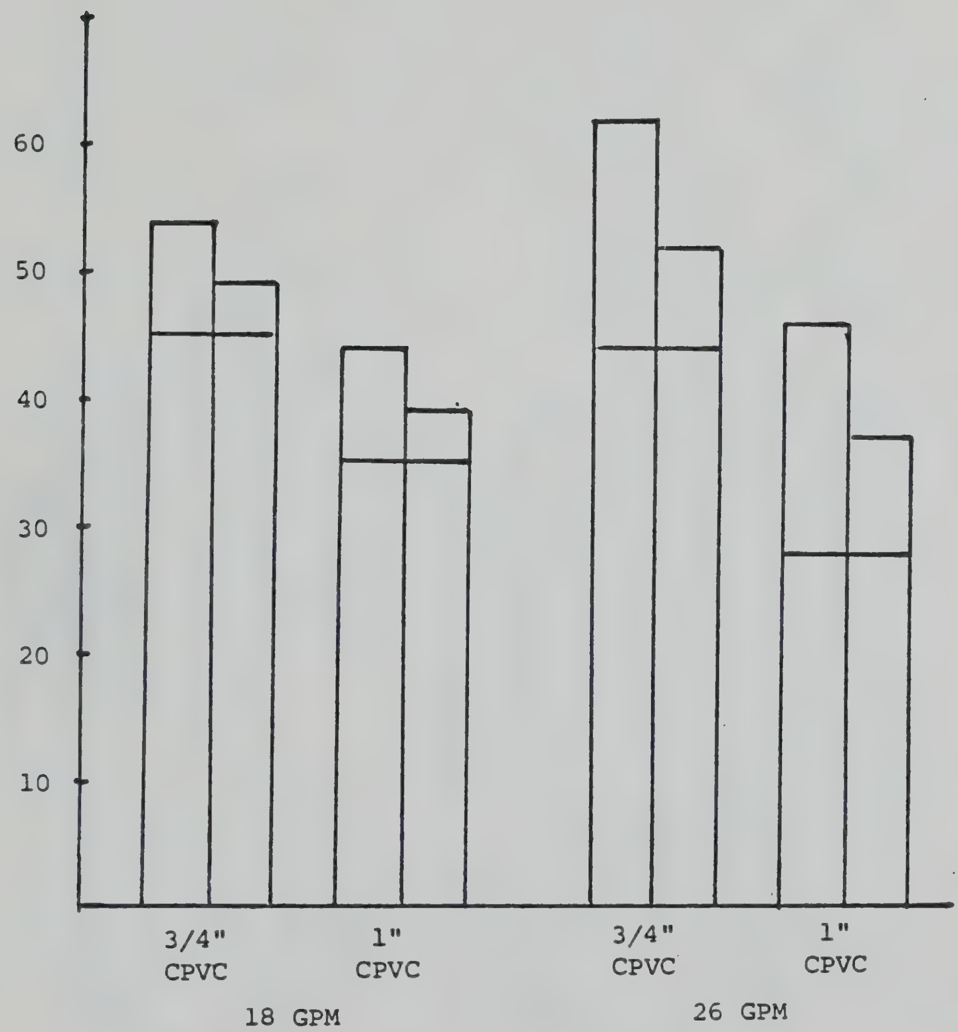


Figure 4. Water Pressure Demand Requirements for Colonial House, 5 Bedrooms (3,480 sq. ft.)

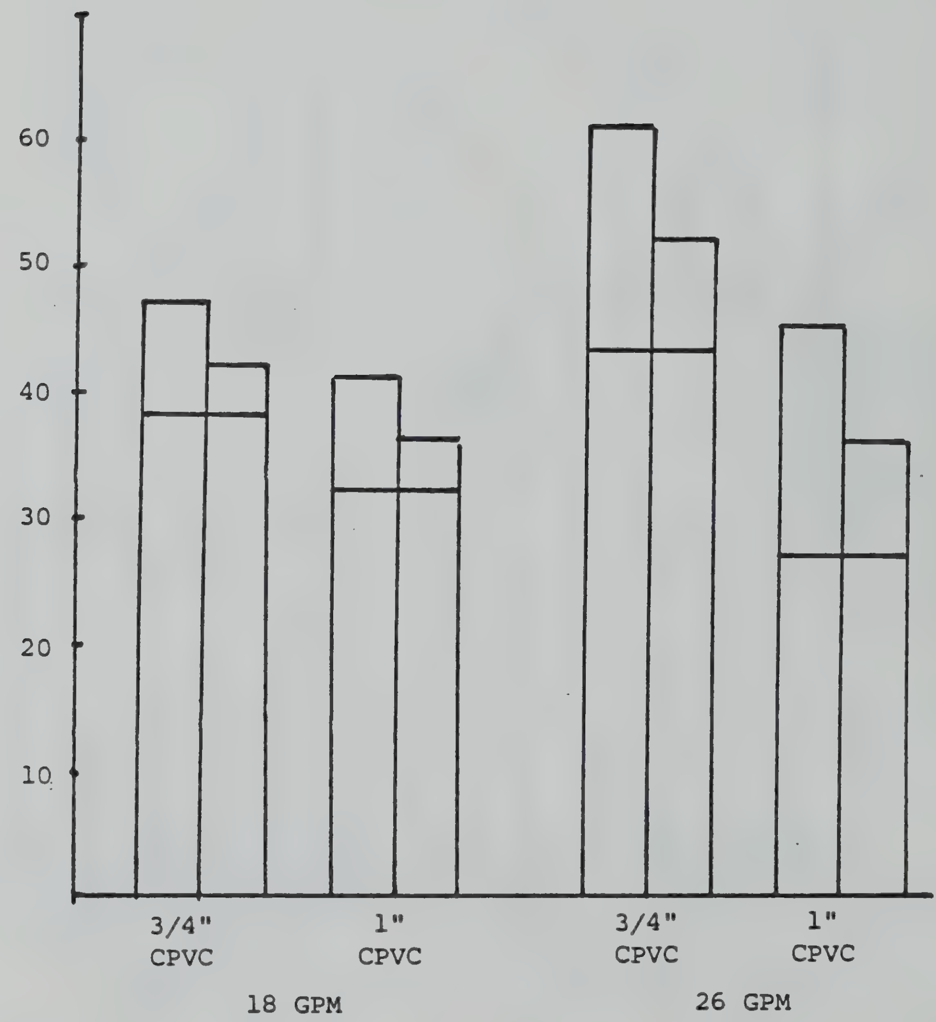


Figure 5. Water Pressure Demand Requirements for Townhouse, 2 Bedrooms (1,690 sq. ft.)

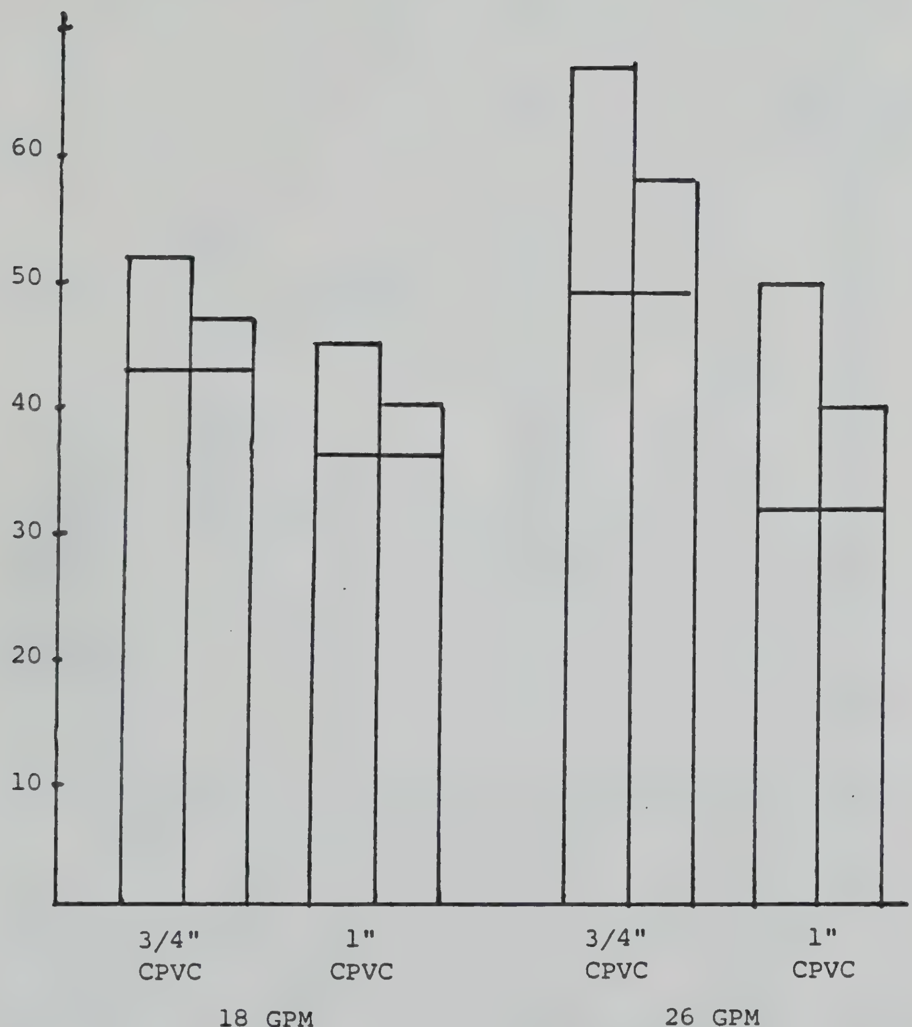


Figure 6. Water Pressure Demand Requirements for Townhouse, 3 Bedrooms (3,360 sq. ft.)

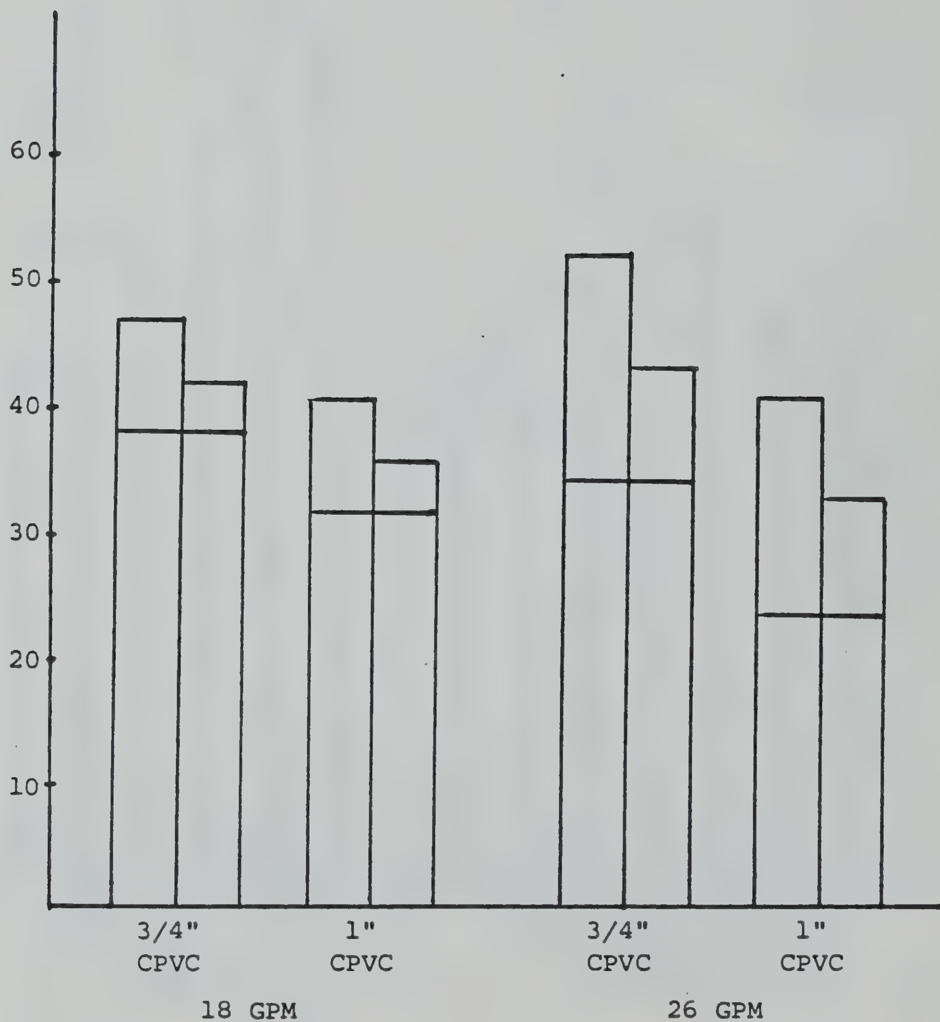


Figure 7. Water Pressure Demand Requirements for Split Level House, 3 Bedrooms (1,945 sq. ft.)

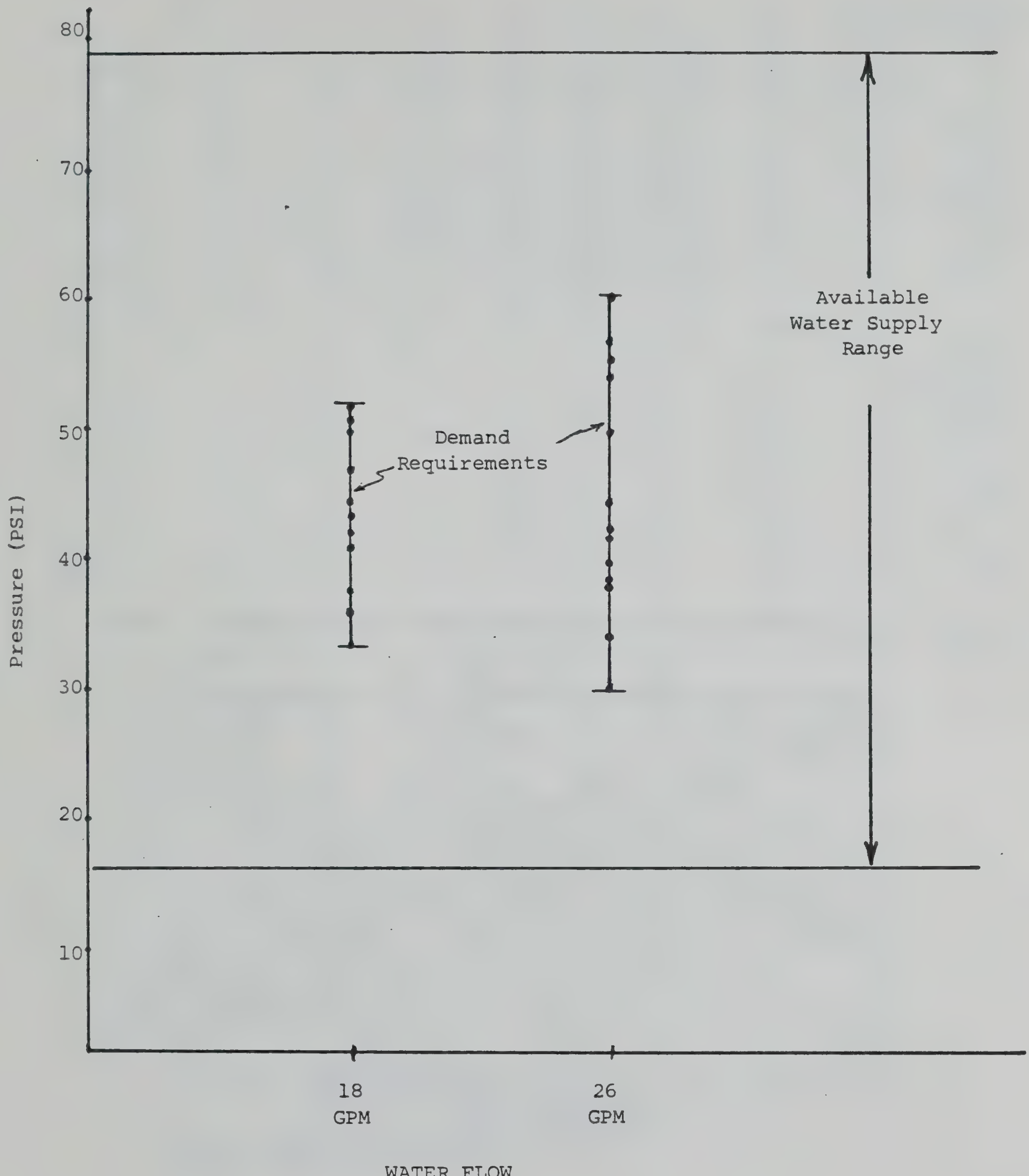


Figure 8   Comparison of Water Demand and Available Water Pressures

CONTRACTOR INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)"CPVC	13	501.00	660.00	476.00	1637.00	141.31	1.24	2386.00	2598.00
(1)" CPVC	13	656.00	932.00	556.00	2144.00	164.92	1.45	2695.00	2905.00
(3/4)" PB	13	489.00	907.00	489.00	1885.00	145.00	1.27	2436.00	2646.00
(1)" PB	13	530.00	858.00	486.00	1874.00	144.15	1.26	2425.00	2635.00
(1)"sch.10 steel pipe	13	329.00	1531.00	651.00	2511.00	193.15	1.69	3062.00	3272.00

OWNER INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)" CPVC	13	501.00	------	------	501.00	38.54	0.34	835.00	944.00
(1)" CPVC	13	656.00	------	------	656.00	50.46	0.44	990.00	1099.00
(3/4)" PB	13	489.00	------	------	489.00	37.62	0.33	823.00	932.00
(1)" PB	13	530.00	------	------	530.00	40.77	0.36	864.00	973.00
(1)" sch.10 steel pipe	13	329.00	------	------	329.00	25.30	0.22	663.00	772.00

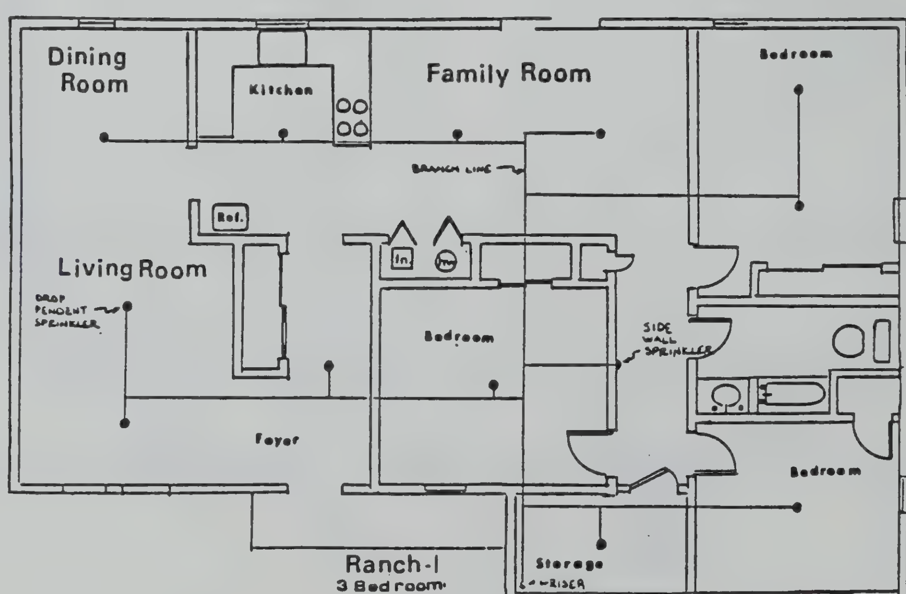


Figure 9. Cost Summary for Ranch House, Style 1, 3 Bedrooms (1,482 sq. ft.) (11,17)

CONTRACTOR INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)"CPVC	18	567.00	1092.00	568.00	2267.00	125.94	1.06	2818.00	3028.00
(1)" CPVC	18	784.00	1183.00	688.00	2655.00	147.50	1.24	3206.00	3416.00
(3/4)"PB	18	576.00	1159.00	607.00	2342.00	130.11	1.09	2893.00	3103.00
(1)" PB	18	617.00	1082.00	595.00	2294.00	127.44	1.07	2845.00	3055.00
(1)"sch.10 steel pipe	18	367.00	1909.00	797.00	3073.00	170.72	1.44	3624.00	3834.00

OWNER INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)" CPVC	18	587.00	------	------	587.00	32.61	0.27	921.00	1030.00
(1)" CPVC	18	784.00	------	------	784.00	43.56	0.37	1116.00	1227.00
(3/4)" PB	18	576.00	------	------	576.00	32.00	0.27	910.00	1019.00
(1)" PB	18	617.00	------	------	617.00	34.28	0.29	951.00	1060.00
(1)" sch.10 steel pipe	18	367.00	------	------	367.00	20.39	0.17	701.00	810.00

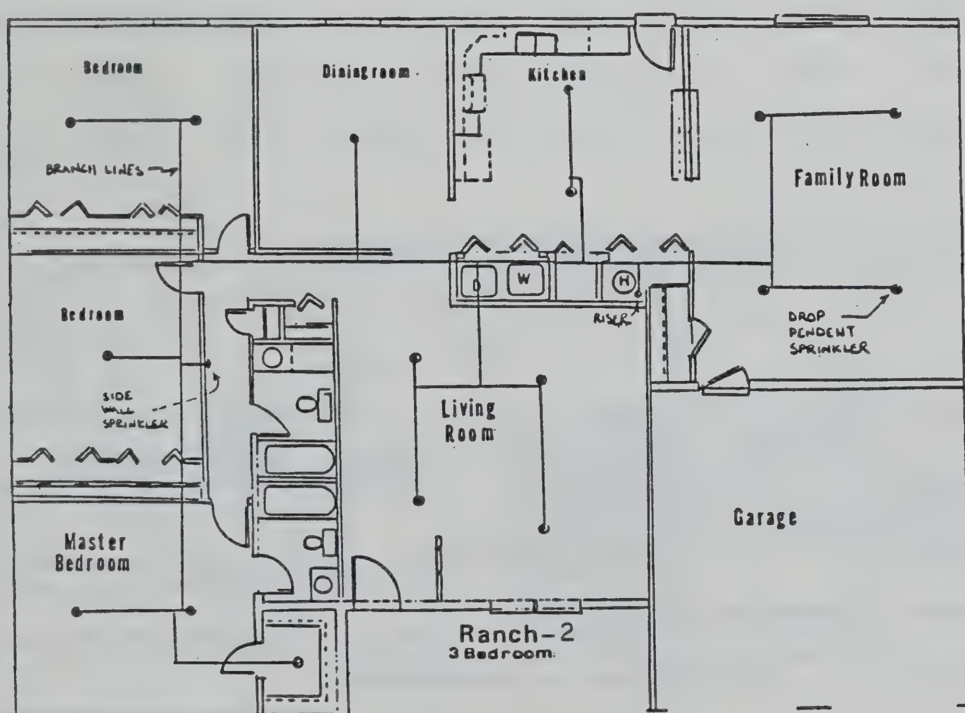


Figure 10. Cost Summary for Ranch House, Style 2, 3 Bedrooms (2,140 sq. ft.) (11,17)

CONTRACTOR INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)" CPVC	19	553.00	1381.00	677.00	2611.00	137.42	1.20	3162.00	3372.00
(1)" CPVC	19	697.00	1449.00	751.00	2896.00	152.89	1.34	3436.00	3666.00
(3/4)" PB	19	545.00	1439.00	694.00	2678.00	140.95	1.24	3229.00	3439.00
(1)" PB	19	579.00	1376.00	684.00	2639.00	138.89	1.22	3190.00	3400.00
(1)" sch.10 steel pipe	19	376.00	1968.00	820.00	3164.00	166.53	1.46	3715.00	3925.00

OWNER INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)" CPVC	19	553.00	------	------	553.00	29.10	0.26	887.00	986.00
(1)" CPVC	19	703.00	------	------	703.00	37.00	0.32	1037.00	1146.00
(3/4)" PB	19	545.00	------	------	545.00	28.68	0.25	879.00	988.00
(1)" PB	19	579.00	------	------	579.00	30.47	0.27	913.00	1012.00
(1)" sch.10 steel pipe	19	376.00	------	------	376.00	19.79	0.17	710.00	819.00

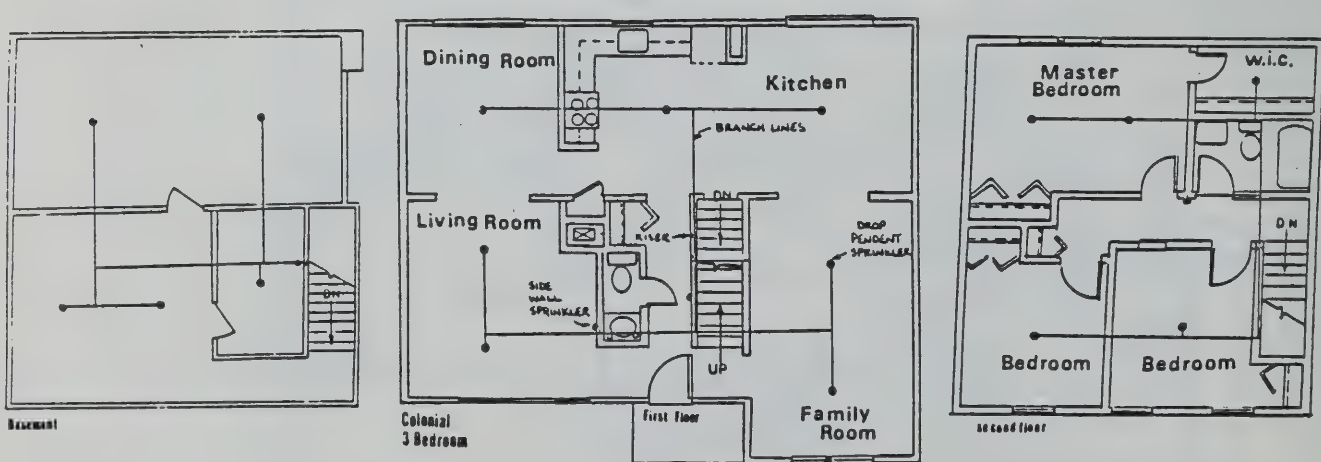


Figure 11. Cost Summary for Colonial House, 3 Bedrooms (2,168 sq. ft.) (11,17)

CONTRACTOR INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)"CPVC	33	892.00	1797.00	941.00	3630.00	110.00	1.04	4180.00	4391.00
(1)" CPVC	33	1218.00	1963.00	1102.00	4283.00	129.78	1.23	4834.00	5044.00
(3/4)" PB	33	839.00	1942.00	973.00	3754.00	113.76	1.08	4305.00	4515.00
(1)" PB	33	942.00	1799.00	959.00	3700.00	112.12	1.06	4251.00	4461.00
(1)"sch.10 steel pipe	33	512.00	3245.00	1315.00	5072.00	153.70	1.46	5623.00	5833.00

OWNER INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)" CPVC	33	892.00	------	------	892.00	27.03	0.26	1226.00	1335.00
(1)" CPVC	33	1218.00	------	------	1218.00	36.91	0.35	1552.00	1661.00
(3/4)" PB	33	839.00	------	------	839.00	25.42	0.24	1173.00	1282.00
(1)" PB	33	942.00	------	------	942.00	28.54	0.27	1276.00	1385.00
(1)" sch.10 steel pipe	33	512.00	------	------	512.00	15.52	0.15	846.00	955.00

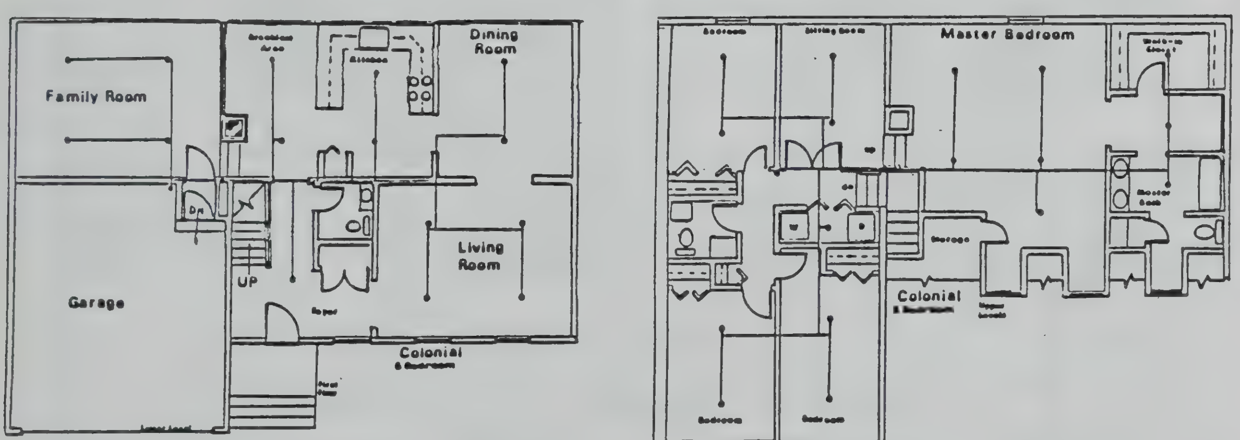


Figure 12. Cost Summary for Colonial House, 5 Bedrooms (3,480 sq. ft.) (11,17)

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
CONTRACTOR INSTALLED									
(3/4)"CPVC	16	563.00	1036.00	560.00	2159.00	134.94	1.28	2710.00	2920.00
(1)" CPV	16	752.00	1063.00	635.00	2450.00	153.12	1.45	3001.00	3211.00
(3/4) "PB	16	638.00	1119.00	615.00	2372.00	148.25	1.40	2923.00	3133.00
(1)" PB	16	554.00	1028.00	554.00	2136.00	133.50	1.26	2687.00	2897.00
(1)"sch.10 steel pipe	16	356.00	1816.00	760.00	2932.00	183.25	1.73	3483.00	3693.00
OWNER INSTALLED									
(3/4)" CPVC	16	563.00	------	------	563.00	35.19	0.33	897.00	1006.00
(1)" CPVC	16	752.00	------	------	752.00	47.00	0.44	1086.00	1195.00
(3/4)" PB	16	638.00	------	------	638.00	39.88	0.38	972.00	1081.00
(1)" PB	16	554.00	------	------	554.00	34.62	0.33	886.00	997.00
(1)" sch.10 steel pipe	16	356.00	------	------	356.00	22.25	0.21	690.00	799.00

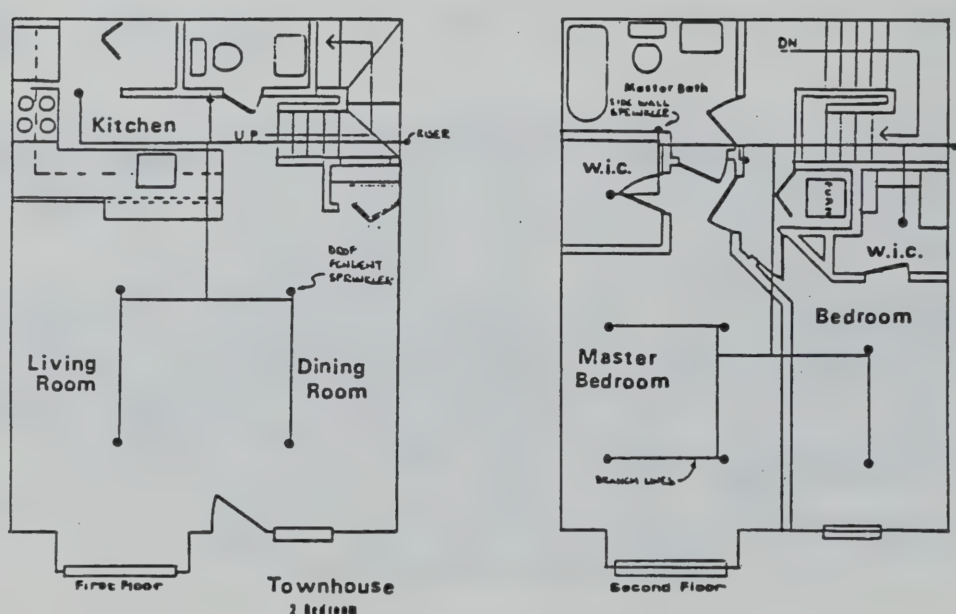


Figure 13. Cost Summary for Townhouse, 2 Bedrooms (1,690 sq. ft.) (11,17)

CONTRACTOR INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)"CPVC	33	772.00	2386.00	1105.00	4263.00	129.18	1.27	4814.00	5024.00
(1)" CPVC	33	1031.00	2502.00	1237.00	4770.00	144.54	1.42	5321.00	5531.00
(3/4)" PB	33	780.00	2474.00	1139.00	4393.00	133.12	1.31	4944.00	5154.00
(1)" PB	33	833.00	2383.00	1126.00	4342.00	131.58	1.29	4893.00	5103.00
(1)"sch.10 steel pipe	33	516.00	3322.00	1343.00	5181.00	157.00	1.54	5732.00	5942.00

OWNER INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)" CPVC	33	772.00	------	------	772.00	23.39	0.23	1106.00	1215.00
(1)" CPVC	33	1031.00	------	------	1031.00	31.24	0.31	1365.00	1474.00
(3/4)" PB	33	780.00	------	------	780.00	23.64	0.23	1114.00	1223.00
(1)" PB	33	833.00	------	------	833.00	25.24	0.25	1167.00	1276.00
(1)" sch.10 steel pipe	33	516.00	------	------	516.00	15.64	0.15	850.00	959.00

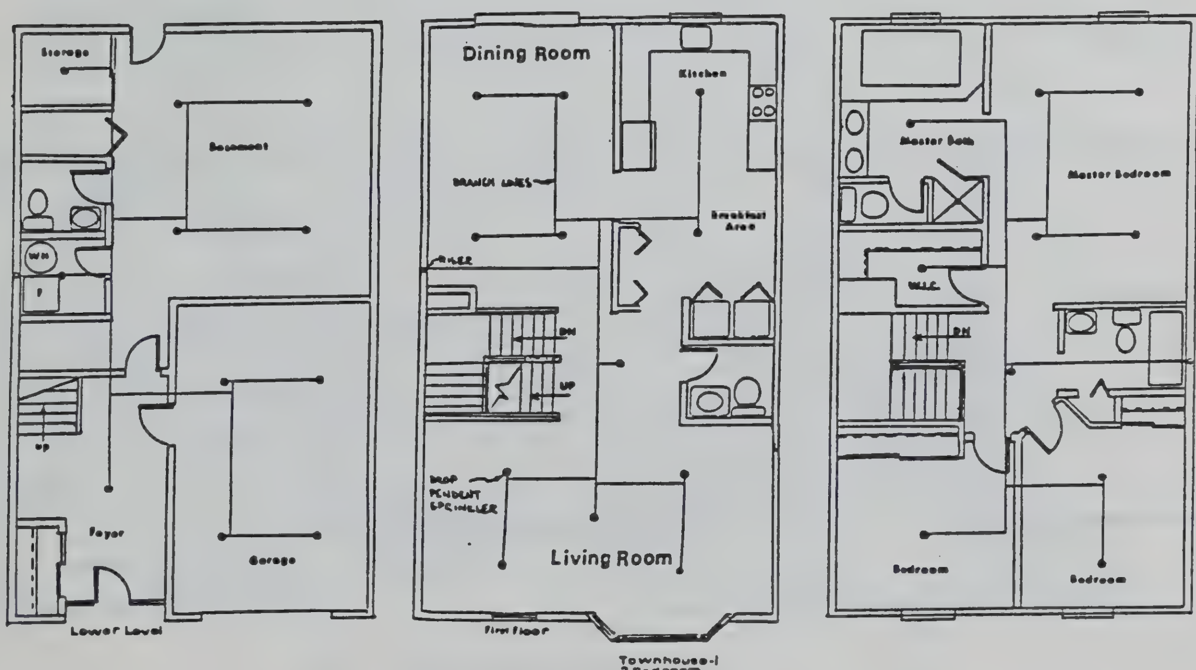


Figure 14. Cost Summary for Townhouse, 3 Bedrooms (3,360 sq. ft.) (11,17)

CONTRACTOR INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)"CPVC	18	519.00	1297.00	636.00	2452.00	136.22	1.26	3003.00	3213.00
(1)" CPVC	18	636.00	1352.00	696.00	2684.00	149.11	1.38	3235.00	3445.00
(3/4)" PB	18	515.00	1358.00	656.00	2529.00	140.50	1.30	3080.00	3290.00
(1)" PB	18	540.00	1294.00	642.00	2476.00	137.56	1.27	3027.00	3237.00
(1)"sch.10 steel pipe	18	367.00	1827.00	768.00	2962.00	164.56	1.52	3513.00	3723.00

OWNER INSTALLED

	number of sprk. heads	systems mat. cost	systems labor cost	overhead & profit	TOTAL COST	cost per head	cost per sq.ft.	TOTAL COST (pump)	TOTAL COST (pump & tank)
(3/4)" CPVC	18	519.00	------	------	519.00	28.83	0.27	853.00	962.00
(1)" CPVC	18	636.00	------	------	636.00	35.33	0.33	970.00	1079.00
(3/4)" PB	18	515.00	------	------	515.00	28.61	0.26	849.00	958.00
(1)" PB	18	540.00	------	------	540.00	30.00	0.28	874.00	983.00
(1)" sch.10 steel pipe	18	367.00	------	------	367.00	20.39	0.19	701.00	810.00

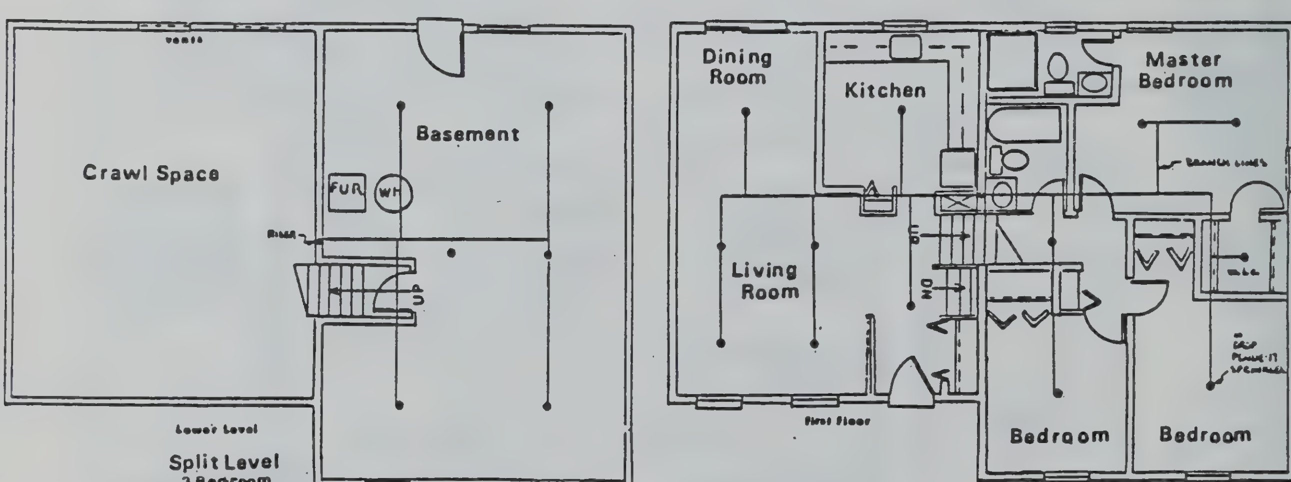


Figure 15. Cost Summary for Split Level House, 3 Bedrooms (1,945 sq. ft.) (11,17)

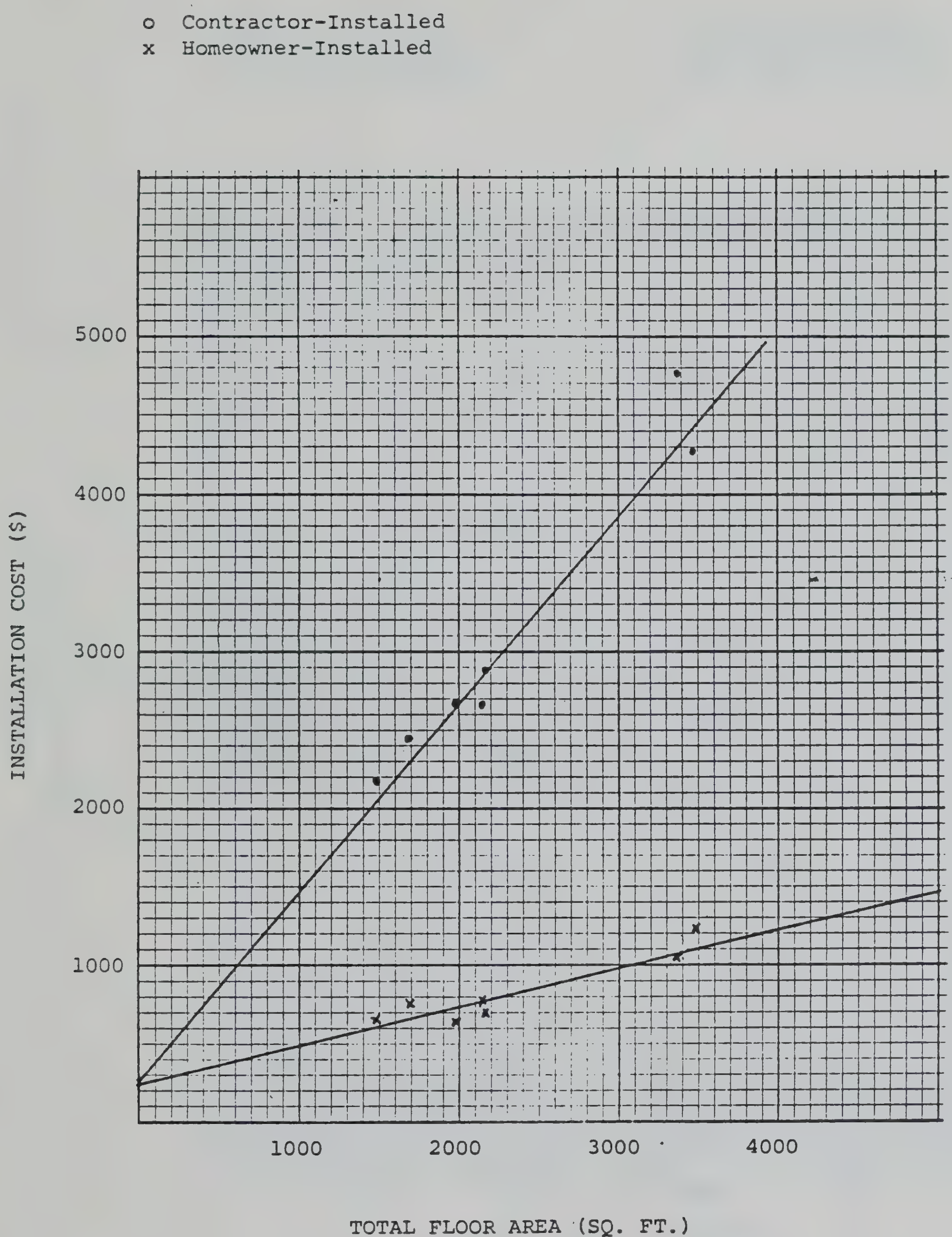


Figure 16. Total Installation Cost versus Floor Area (3/4" CPVC)

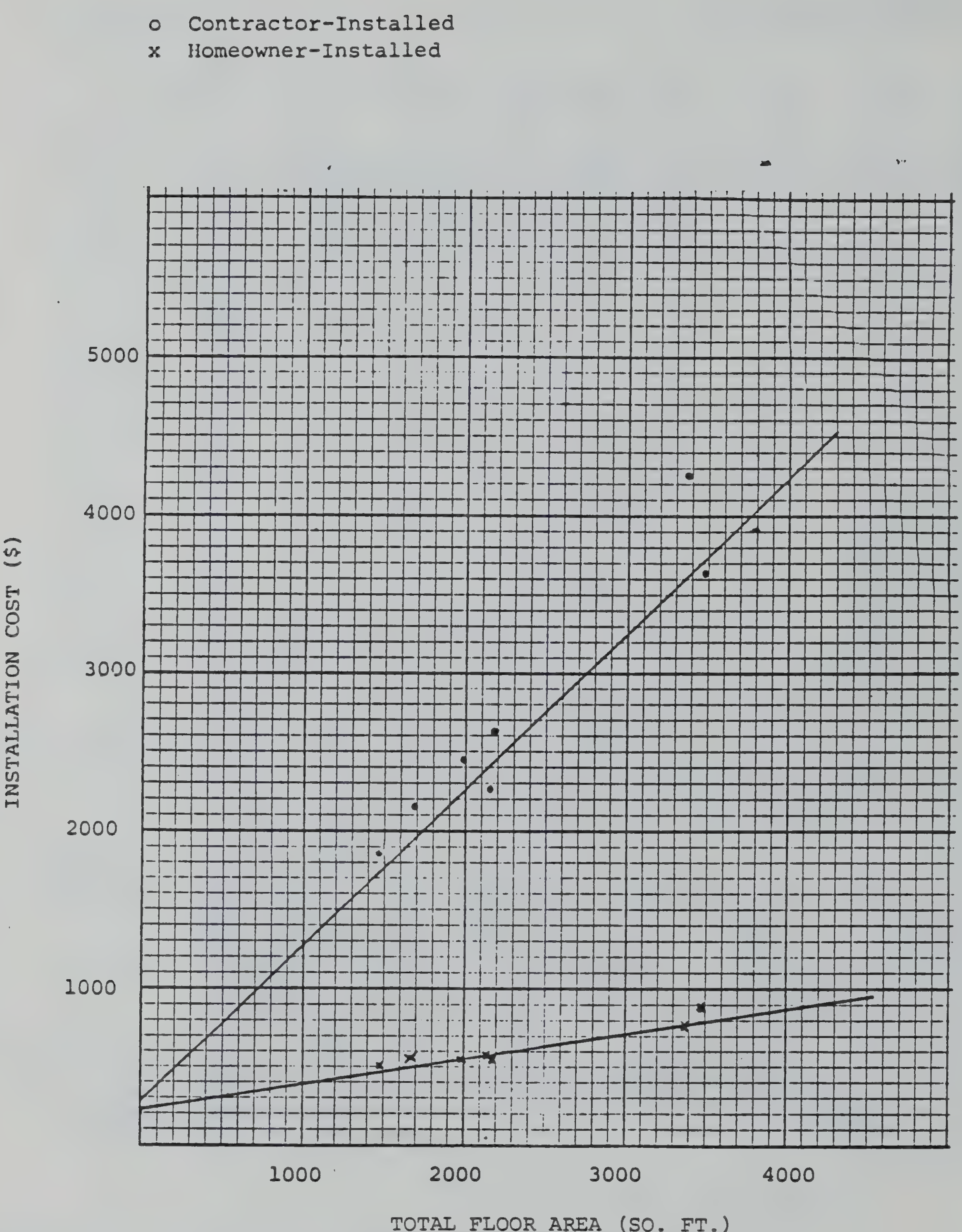


Figure 17. Total Installation Cost versus Floor Area (1" CPVC)

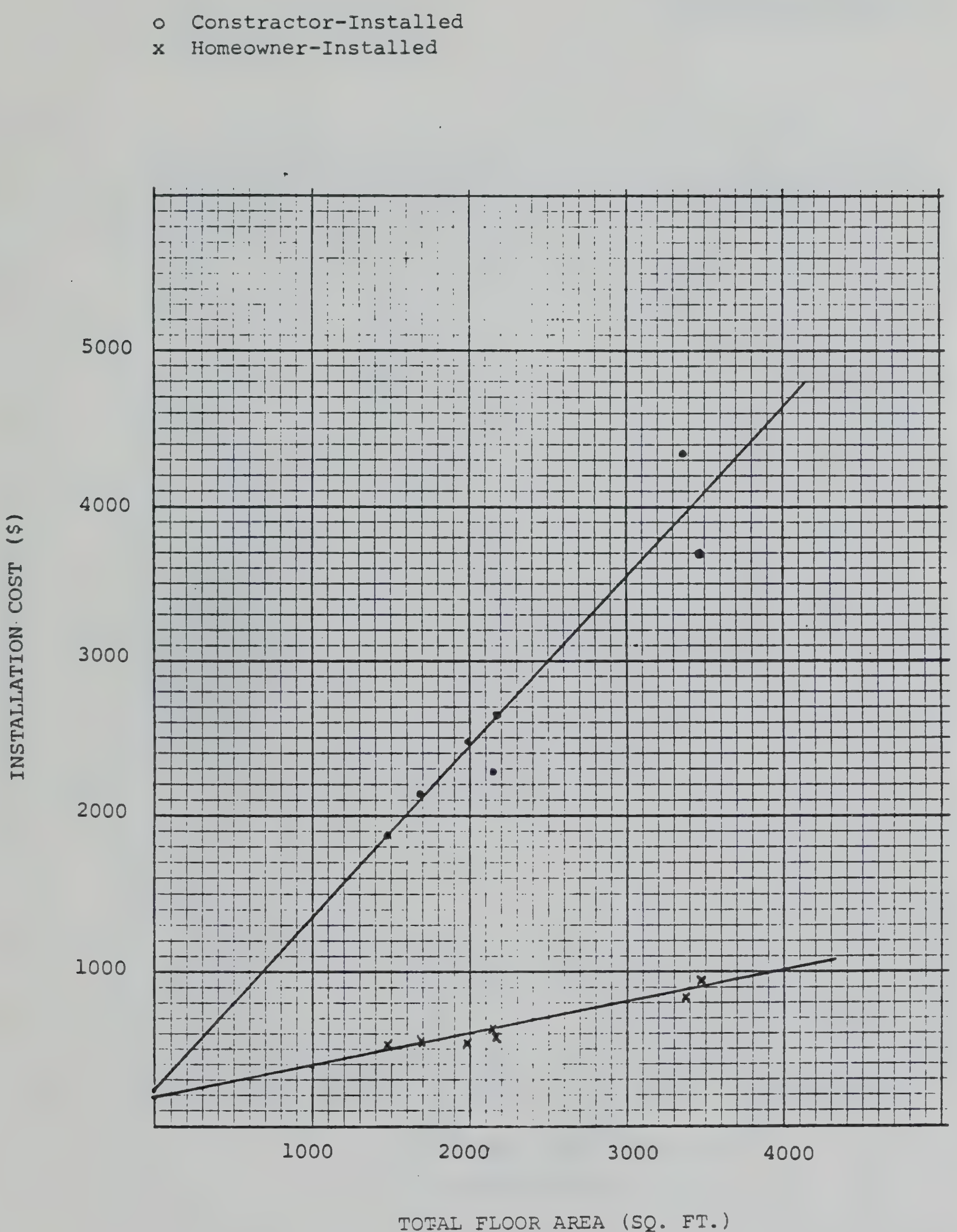


Figure 18. Total Installation Cost versus Floor Area (3/4" PB)

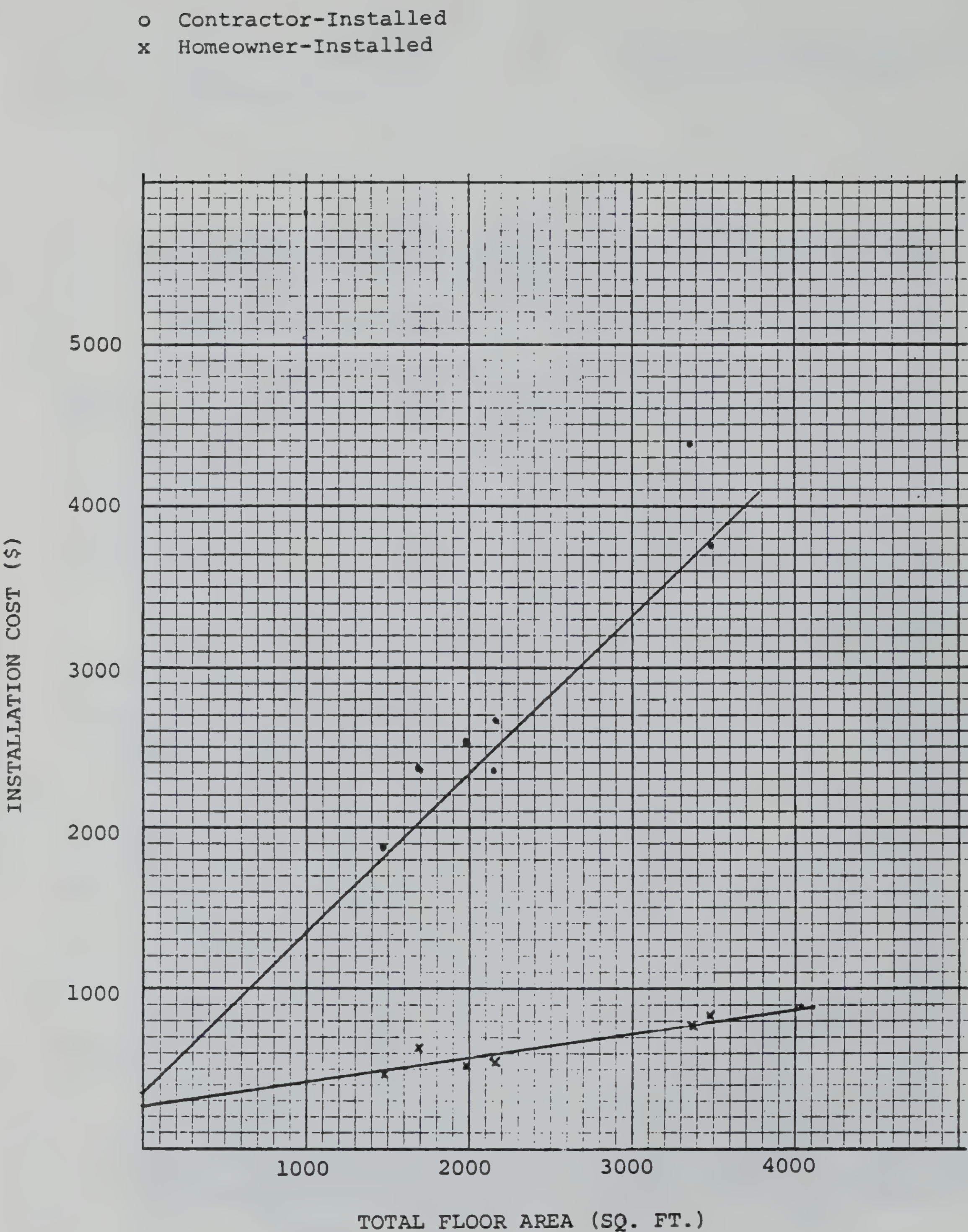


Figure 19. Total Installation Cost versus Floor Area (1" PB)

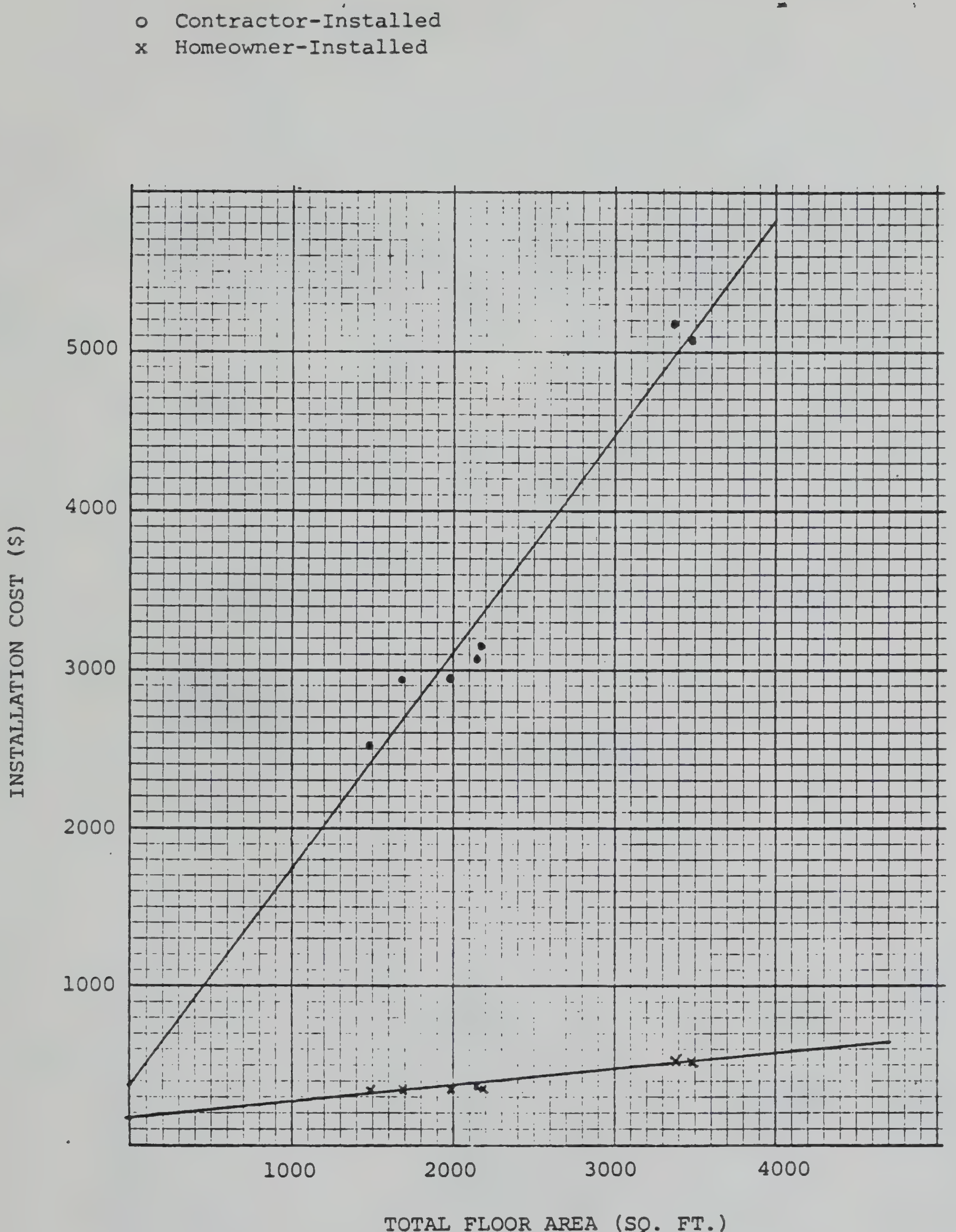
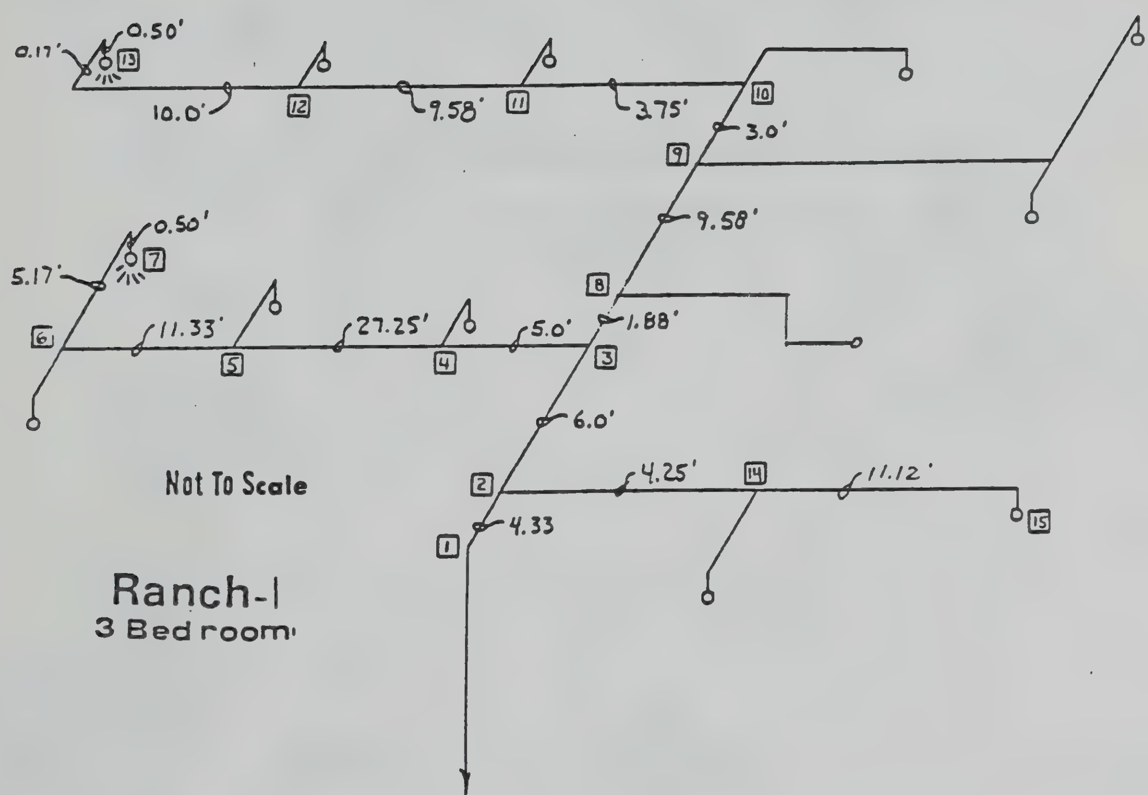
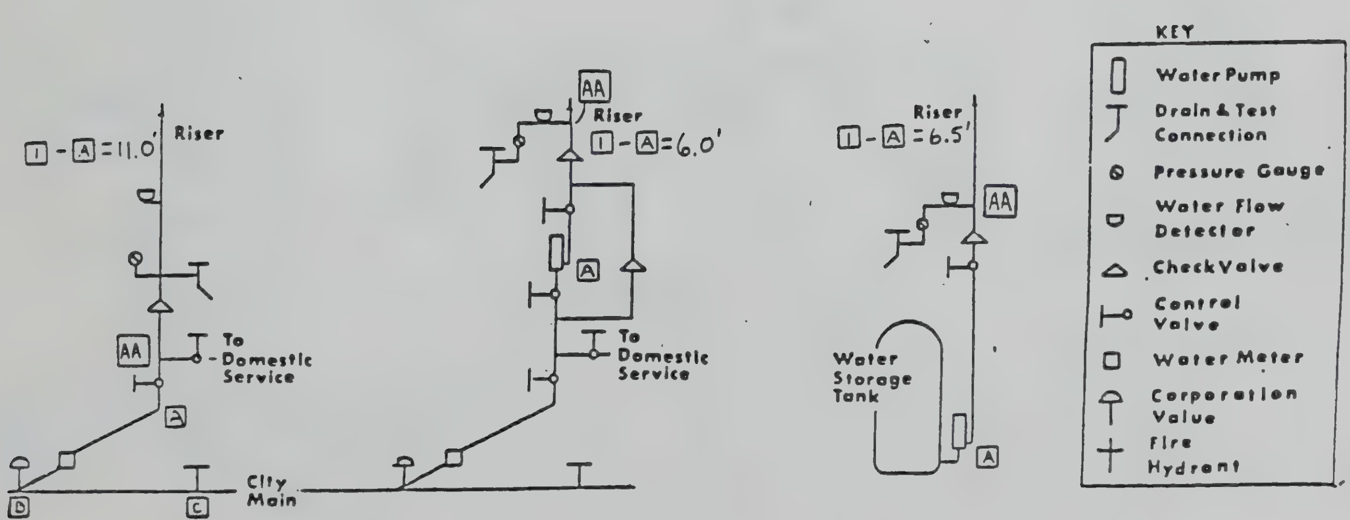
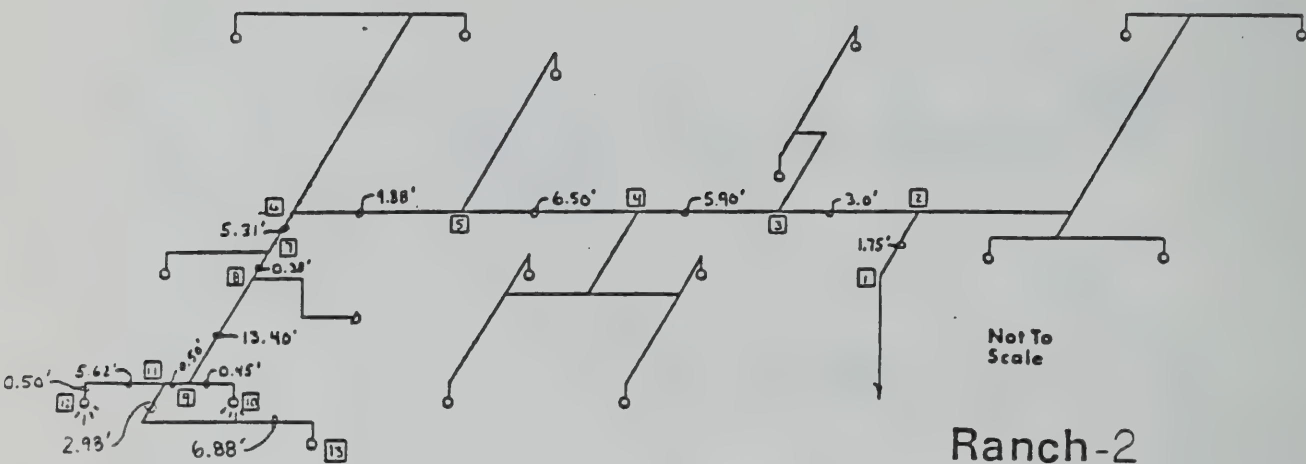


Figure 20. Total Installation Cost versus Floor Area (1" Schedule 10 Steel)

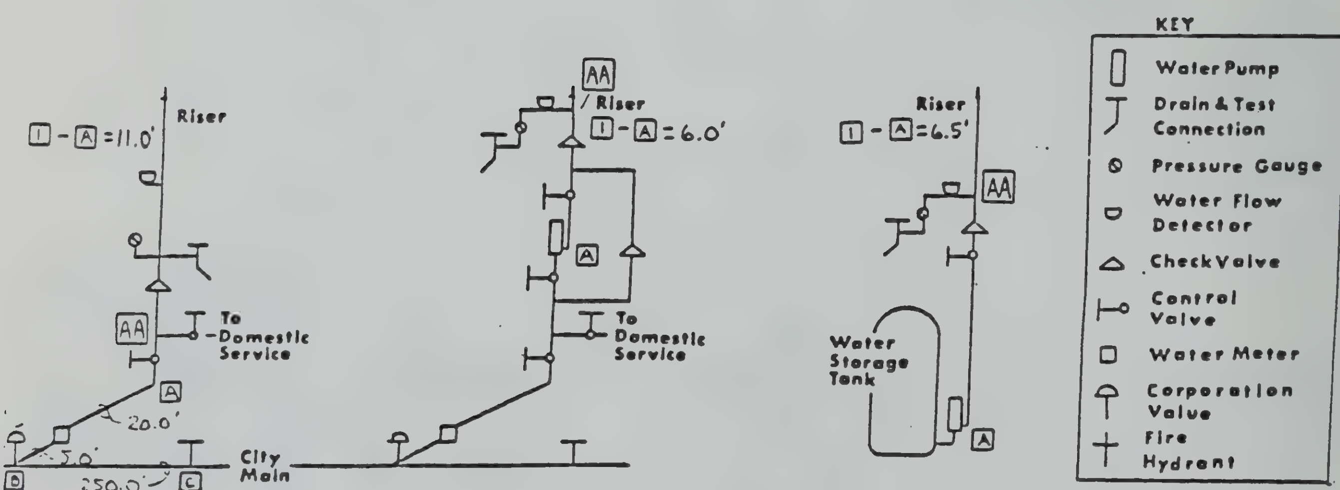
APPENDIX A


0.17'
0.50'
13
10.0'
12
9.58'
11
3.75'
10
3.0'
9
9.58'
0.50'
7
5.17'
8
1.88'
6
11.33'
5
27.25'
4
5.0'
3
6.0'
Not To Scale
2
4.25'
14
11.12'
15
1
4.33
Ranch-1
3 Bedroom


1 - A = 11.0'
Riser
AA
To
Domestic
Service
A
D
C
City
Main
AA
Riser
1 - A = 6.0'
A
To
Domestic
Service
Riser
1 - A = 6.5'
AA
Water
Storage
Tank
A
KEY
Water Pump
Drain & Test
Connection
Pressure Gauge
Water Flow
Detector
Check Valve
Control
Valve
Water Meter
Corporation
Valve
Fire
Hydrant

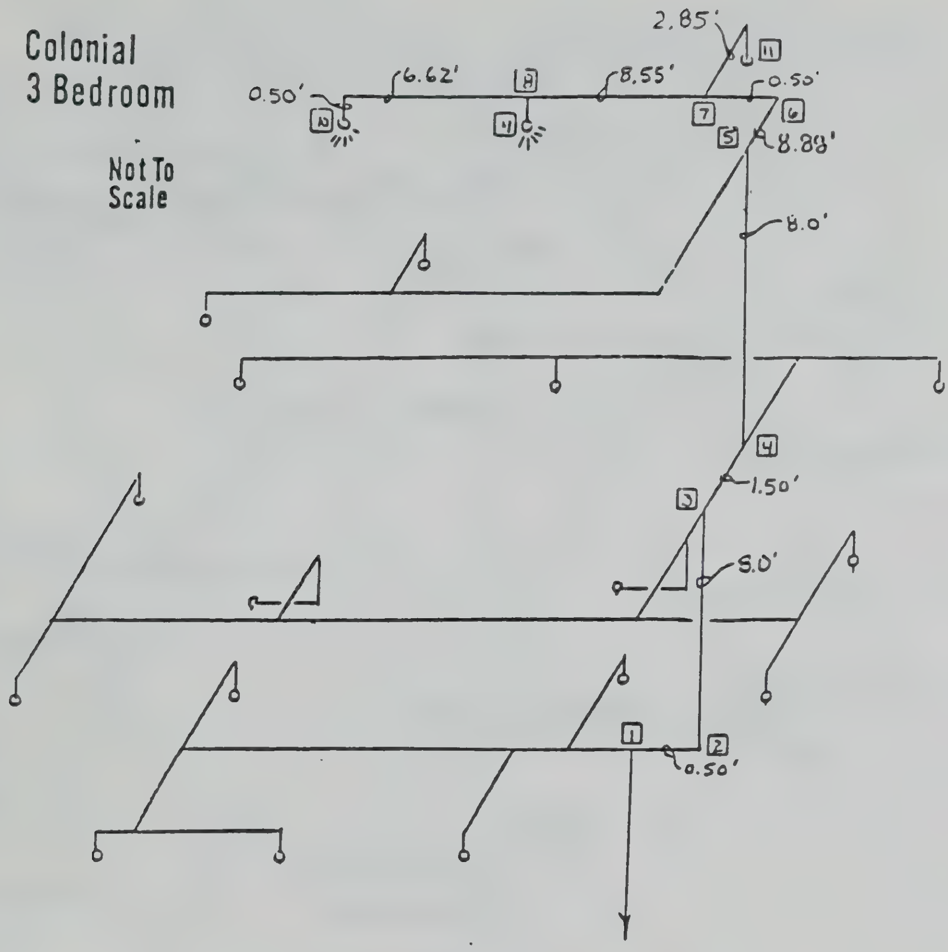


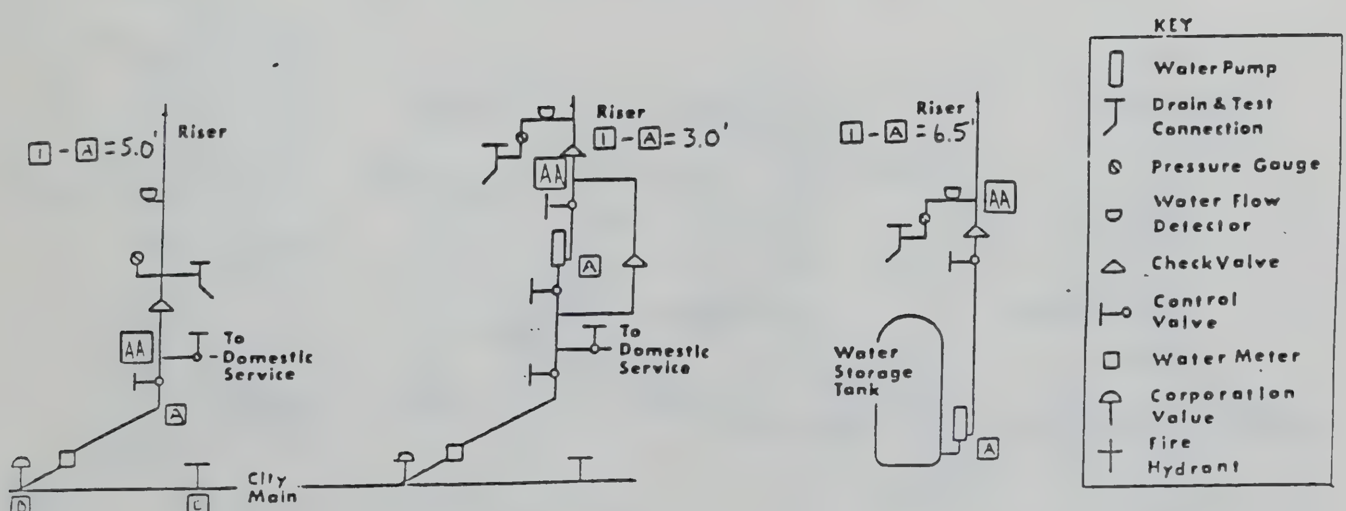
Ranch-2
3 Bedroom

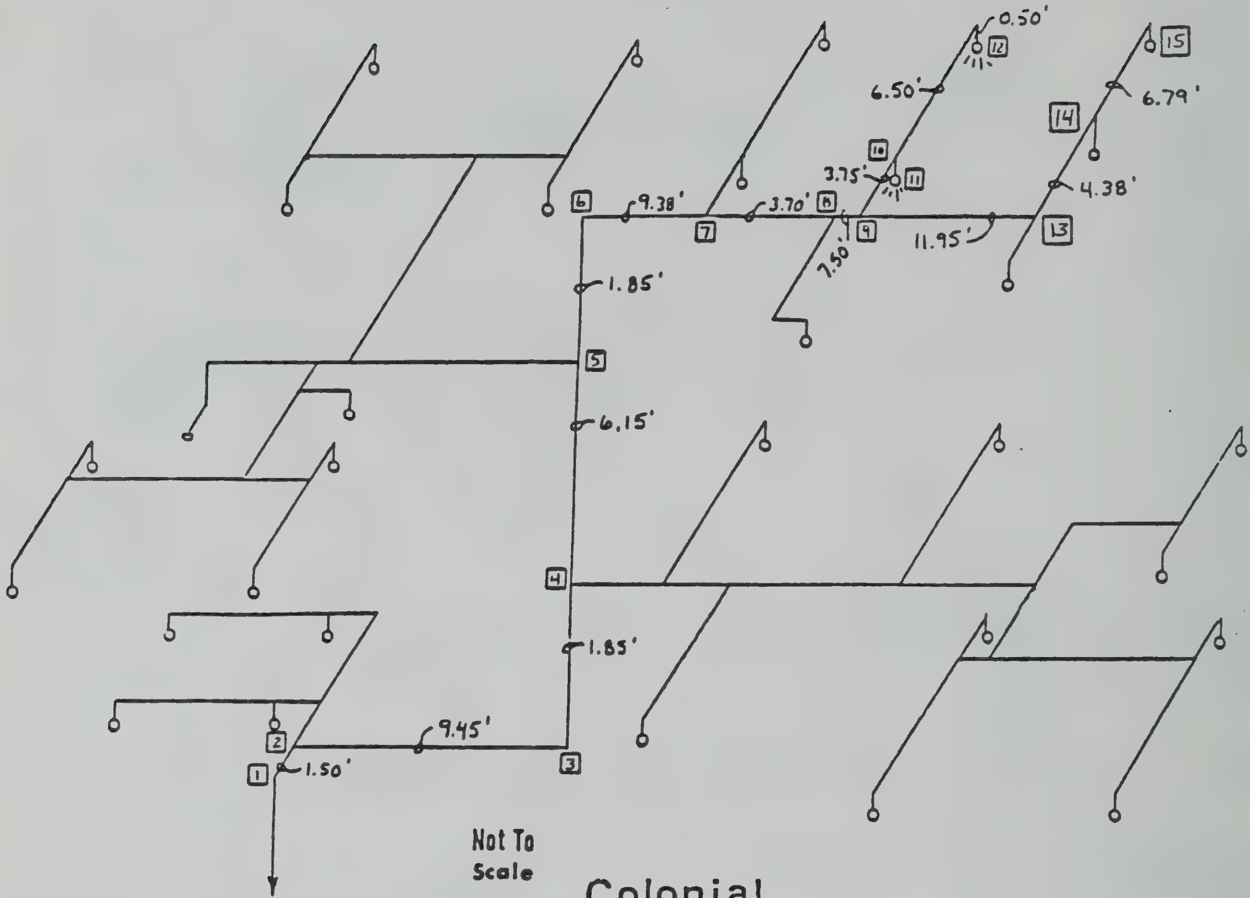


Colonial
3 Bedroom

Not To
Scale

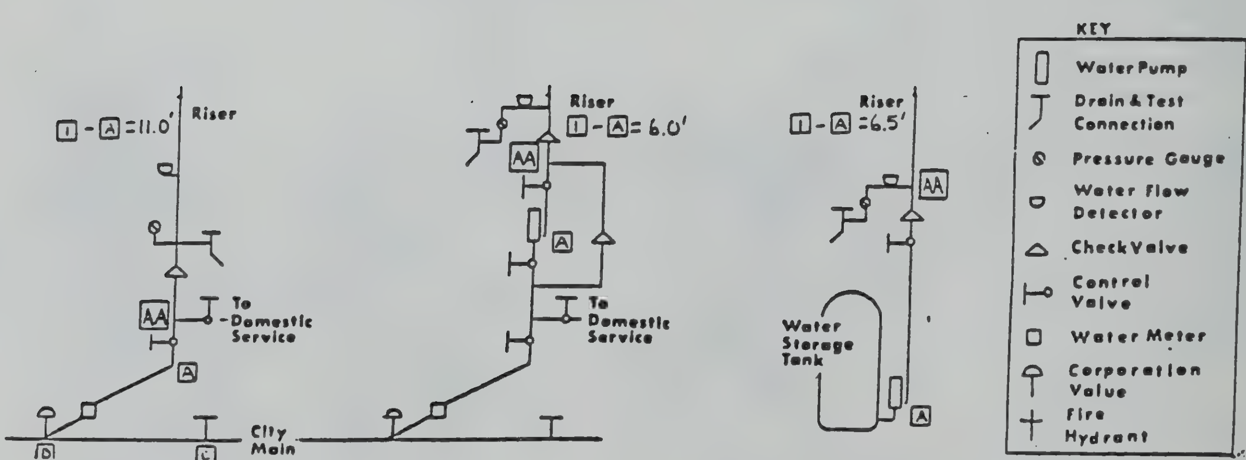


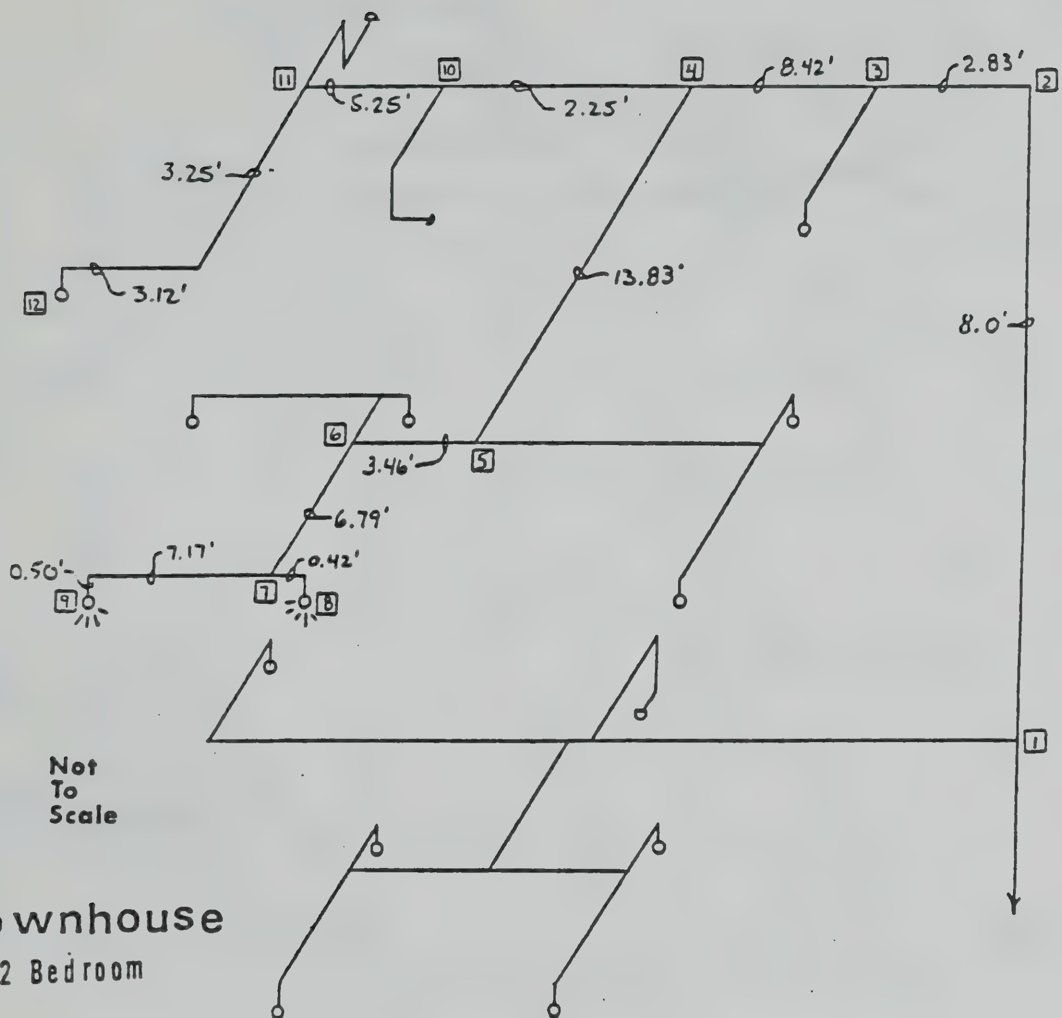




Colonial

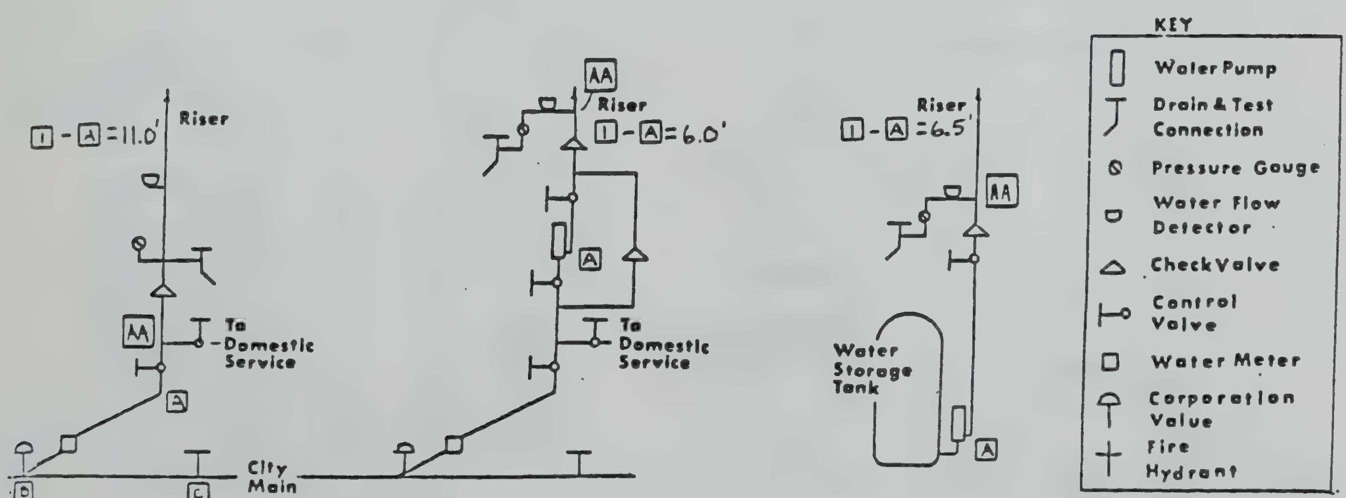
5 Bedroom

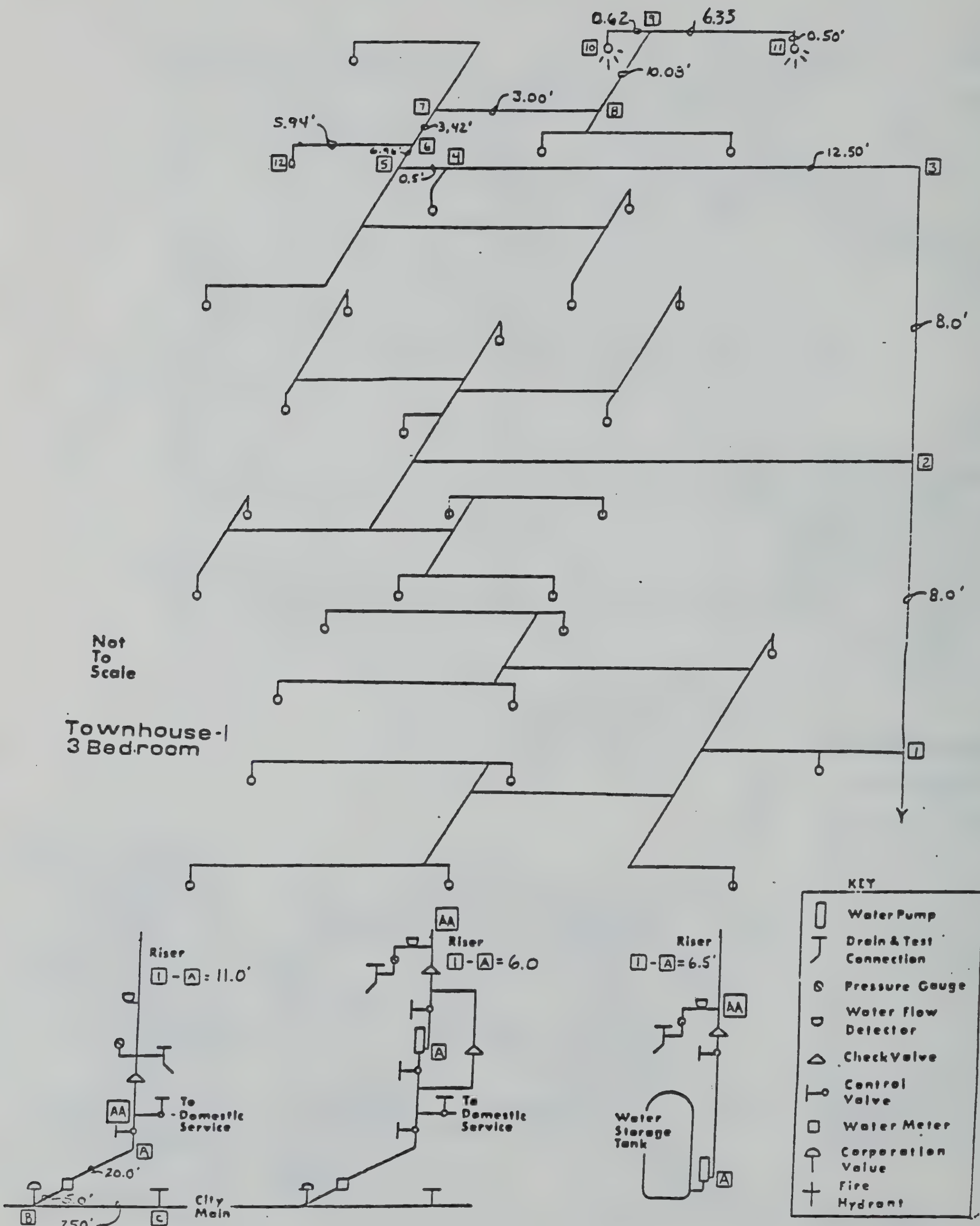


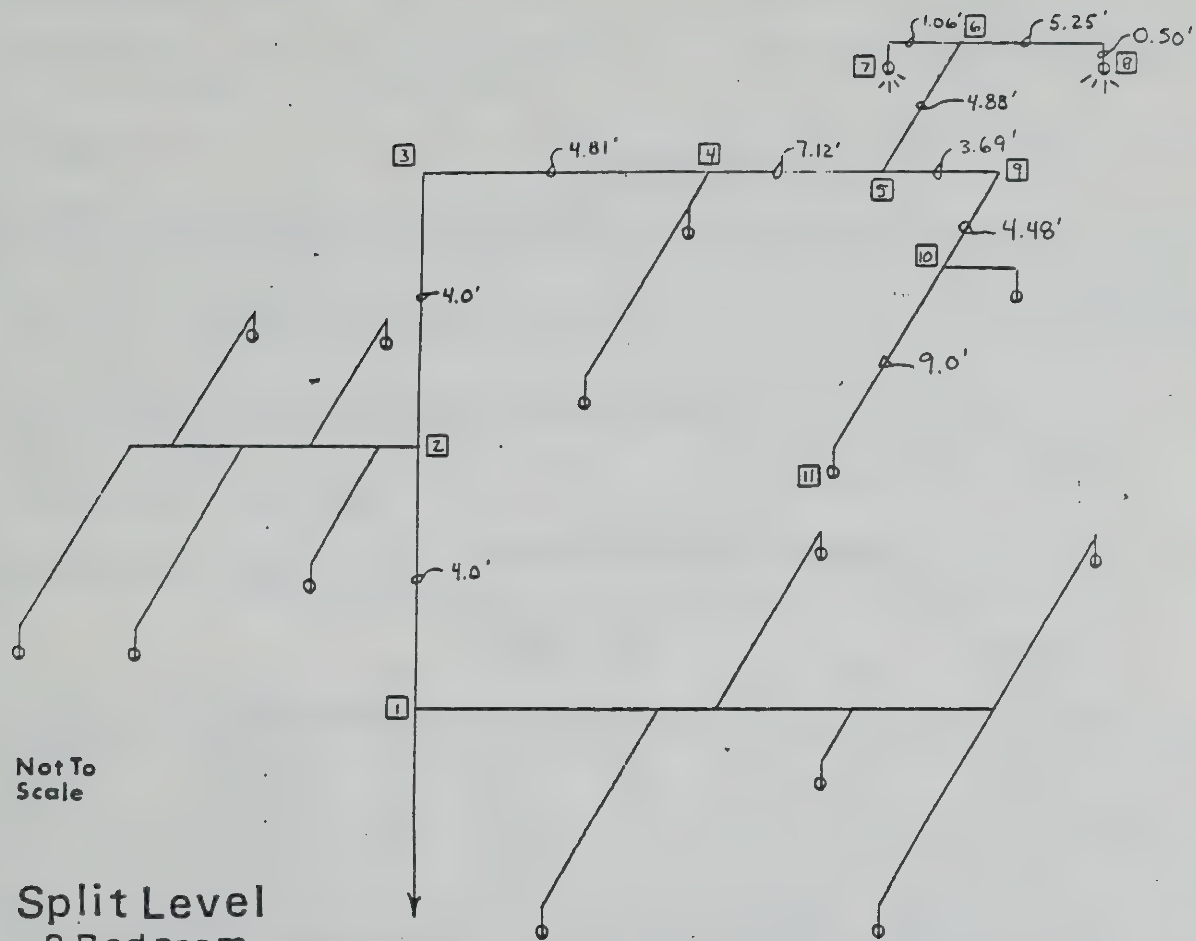


Townhouse

2 Bedroom




0.62
9
6.33
10
11
0.50'
10.03'
7
3.00'
8
5.94'
3.42'
6
12
5
4
12.50'
3
0.5'
8.0'
2
8.0'
Not
To
Scale
Townhouse-1
3 Bedroom
1
Riser
1 - A : 11.0'
AA
To
Domestic
Service
A
20.0'
5.0'
B
250'
C
City
Main
AA
Riser
1 - A = 6.0
A
To
Domestic
Service
Riser
1 - A = 6.5'
AA
Water
Storage
Tank
A
KEY
Water Pump
Drain & Test
Connection
Pressure Gauge
Water Flow
Detector
Check Valve
Control
Valve
Water Meter
Corporation
Valve
Fire
Hydrant


1.06'
6
5.25'
0.50'
7
8
4.88'
3
4.81'
4
7.12'
3.69'
9
5
4.48'
10
4.0'
9.0'
2
11
4.0'
1
Not To Scale
Split Level
3 Bedroom

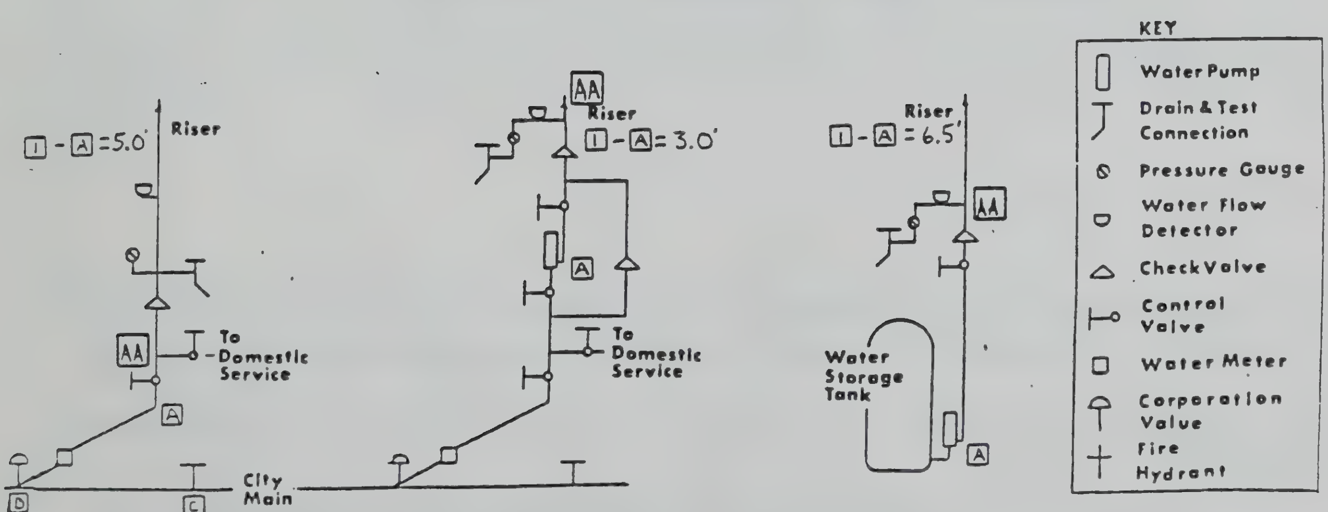

1 - A = 5.0'
Riser
AA
To Domestic Service
A
D
C
City Main
AA
Riser
1 - A = 3.0'
A
To Domestic Service
Riser
1 - A = 6.5'
AA
Water Storage Tank
A
KEY
Water Pump
Drain & Test Connection
Pressure Gauge
Water Flow Detector
Check Valve
Control Valve
Water Meter
Corporation Valve
Fire Hydrant

Table 4-4.3 (d)
Pressure Losses in Water Meters

Meter (Inches)	Pressure Loss (psi) Flow (gpm) 18	23	26	31	39	52
5/8	9	14	18	26	*	*
3/4	4	8	9	13	*	*
1	2	3	3	4	6	10
1-1/2	**	1	2	2	4	7
2	**	**	**	1	2	3

NOTE: Lower pressure losses may be used when supporting data is provided by the meter manufacturer.
* Above maximum rated flow of commonly available meters.
** Less than 1 psi.

For SI Units: 1 gpm = 3.785L/min; 1 in. = 25.4 mm

from NFPA 13D (10)

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Development of Cost Effective Techniques for Alleviating Water Supply Deficiencies in a Residential Sprinkler System

5. AUTHOR(S)

James A. Milke and Dr. John L. Bryan

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)*

University of Maryland
Dept. of Fire Protection Engineering
College Park, MD 20742

7. Contract/Grant No.

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8. Type of Report & Period Covered

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National Bureau of Standards
Center for Fire Research
Gaithersburg, MD 20899

and

U.S. Fire Administration
Emmittsburg, MD 21727

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

Simple cost effective techniques for alleviating water supply deficiencies in a residential sprinkler system installed in a one- or two-family dwelling have been examined. The equipment associated with compensating for an inadequate municipal water supply using water storage tanks, booster pumps, and large diameter pipe have been investigated for efficiency and cost effectiveness. Hydraulically-designed, NFPA 13D, residential sprinkler systems in seven residences were used to carry out this research. The seven selected floor plans of one- and two-family dwellings included in this project were representative of a wide range of designs currently being utilized in actual residential subdivisions under construction at the time of the project in the Baltimore-Washington area. The simple technique for determining the installation cost of a sprinkler system was formulated following an analysis of the sprinkler system versus the key design features of the dwelling. Emphasis was placed on developing a technique which was accurate and easy to apply with minimal time and effort.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

fire suppression; residential sprinklers; sprinkler installation; sprinkler systems; water supply

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